Vol. 53 No. 3 January 1960

Quarterly

of the

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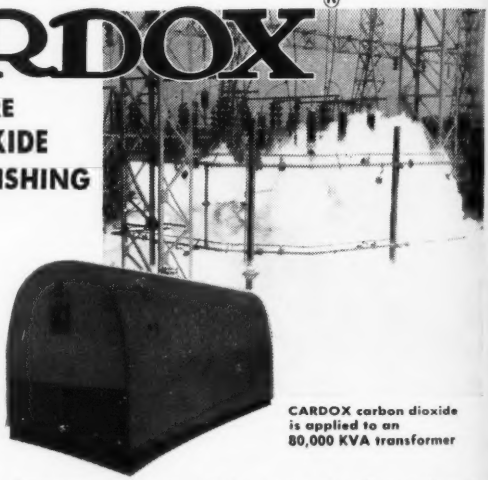

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Vol. 53 No. 3 January 1960

Quarterly

The Standard Technical Journal of Fire Protection for More Than Fifty Years

The NFPA is a non-profit technical and educational organization devoted to the reduction of loss of life and property by fire with a total membership of 17,000. The *Quarterly* is one of the publications regularly provided to members. Other membership publications include *Fire News*, *Advance Reports* to the Annual Meeting, a *Year Book*, and many leaflets, pamphlets and posters issued throughout the year on fire prevention and control. Six volumes of the National Fire Codes are available on an annual subscription basis, one volume free and others at reduced membership rates. For full details on available material ask for a free list of "Publications on Fire Prevention and Protection."

NFPA annual dues are $15.00 for Associate Membership of which $6.00 is for subscription to this Journal. National and regional societies or associations may apply for an organization membership for which annual dues are $100; such a membership entitles four individuals to receive the periodical membership publications.

Technical committees of the Association develop means to safeguard life and property through the publication of standards covering all phases of fire prevention and protection. Your membership in the Association affords an opportunity to keep abreast of these developments and, by being a member, you help support this humanitarian activity. Popular educational literature on fire safety is constantly being produced by the NFPA for distribution through its members to the general public.

National Fire Protection Association

International

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Quarterly

of the

NATIONAL FIRE PROTECTION ASSOCIATION

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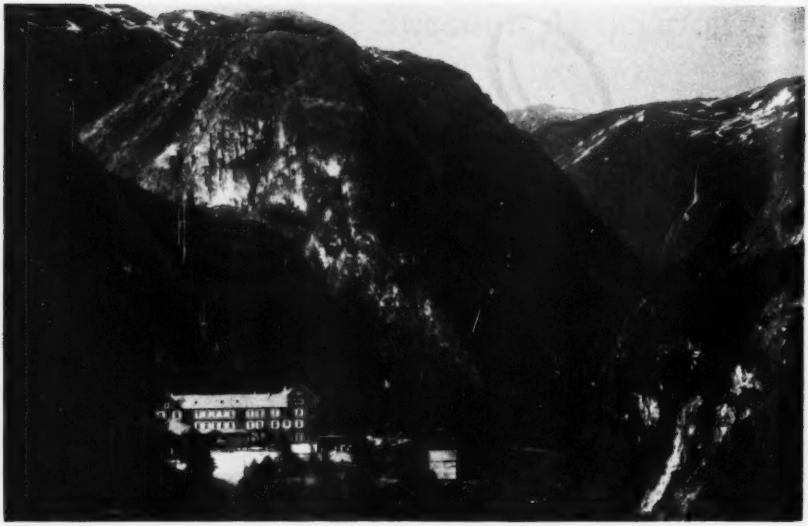
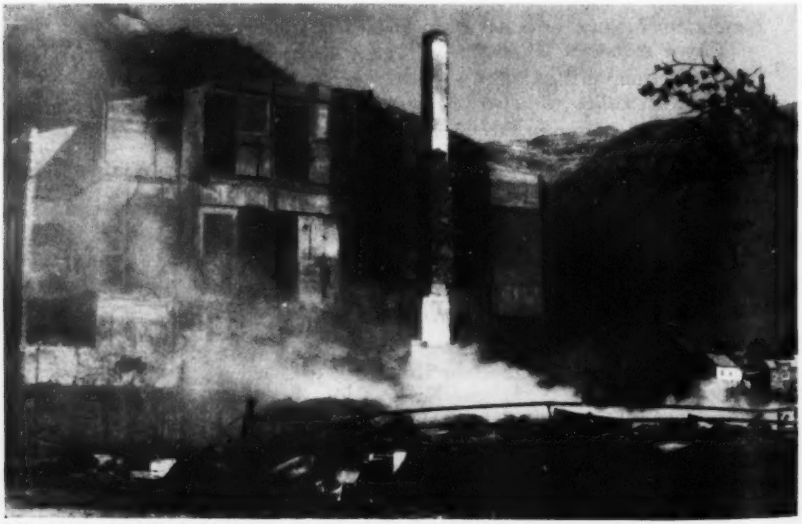


Mittet Foto

Twenty-six guests lost their lives and many others were injured in a fire that leveled the Stalheim Hotel, at Stalheim, Norway, on June 23, 1959. The 74-year-old resort hotel was a 99-room, 3-story wooden building built on the side of a steep mountain, and was a favorite stopping place for thousands of tourists annually. It was remote from public fire protection, was honeycombed with open corridors and stairways, and had no automatic sprinkler protection.

Police attributed the fire to smoking in bed by a guest in a second-story room. When the fire was discovered by another guest at about 3 A.M., corridors and stairways were filling rapidly with smoke. Guests were alerted by the building's manually operated alarm system but on finding smoke in the corridors many of the 147 guests stayed in their rooms where they were trapped as flames quickly engulfed the building. Many panic-stricken guests were injured or killed as they fought their way through smoke and flames or jumped from windows.



Birkhaug & Omdal og Bergens Tidende

Fire Protection Developments in 1959

By Percy Bugbee

General Manager, National Fire Protection Association

Member, Society of Fire Protection Engineers

Estimates of U. S. fire loss for 1959 indicate a slight reduction in deaths from fire and also a slight reduction in amount of property loss. Our preliminary figures indicate 11,300 fire deaths in 1959 and property losses of $1,275,000,000. Estimates of the U. S. losses for the past decade are 116,000 people killed in fires and property damage of eleven billion dollars!

There were a number of fires in 1959 which attracted wide attention. Two of these involved the transportation of liquefied petroleum gas. The first occurred near Pottsville, Pa., on June 2. An LP-Gas tank truck had stopped on the highway behind a school bus and was hit at the rear by another truck. Eleven people watching the ensuing fire lost their lives and 10 others were injured when the cargo tank ruptured and rocketed about 1,000 feet. The other occurred when a freight train was derailed while passing over a trestle spanning the Ogeechee River near Meldrim, Ga., on June 28. Two LP-Gas tank cars plunged down an embankment into a picnic area. Due to the fact that a car coupler or draw bar pierced one of the LP-Gas tank cars, the flammable gas was released in a cloud and ignited, probably at a picnic fire. Twenty-three persons lost their lives. Both of these incidents were investigated and reported on in detail by the NFPA Gases Field Engineer.*

The fire in the Pentagon on July 2 in the Air Force Statistical Division caused heavy loss of electronic computers and magnetic tape† and aroused great interest in the problem of adequate fire protection for electronic computer systems. This has led to the creation of an NFPA technical committee in this field.

The explosion of a truck carrying explosives parked unattended near a building which caught fire in Roseburg, Oregon, on August 7, focused attention again on the hazards of truck transportation of explosives and other dangerous materials. Thirteen people were killed in this tragedy which is reported in detail on pages 195 to 207 of this issue of the QUARTERLY.

In Kansas City, Kansas, on August 18, a fire starting at a loading rack of a combined bulk plant and service station resulted in the explosion of an inadequately vented aboveground gasoline storage tank and caused six deaths and 64 injuries to firemen. Here again the NFPA made a personal investigation and a report of the incident was prepared by the NFPA Flammable Liquids Engineer.‡ Included in this issue of the QUARTERLY is a special article on the problems of inadequate vents on flammable liquid tanks (see pages 208 to 216).

Fatal Residential Fires

We continue to be very much concerned with the number of fatal fires that occur, for the most part, in cold

*The Pottsville accident was reported in the October 1959 QUARTERLY and has been reprinted in pamphlet form (Q53-1). The Meldrim accident was reported in the August 1959 *Fire News*.

†This fire was reported in the August 1959 *Fire News*.

‡See the November 1959 issue of *Firemen* Magazine. This article has been reprinted and is available from the NFPA (F26-10).

weather and in most cases in dwellings and multiple dwelling occupancies.

In January of 1959, for instance, a list of the residential fires taking 6 or more lives includes a fire in an apartment building in Rochester, N. Y., on January 1 which took the lives of six people; on the same day, a fire in a dwelling in Vincennes, Indiana, also took six lives. On January 5 in Winstonville, Miss., 6 were killed in a dwelling. On January 6, seven lives were lost in a college dormitory in Syracuse, N. Y. In Brandon, Minn., a father and five children perished in a dwelling fire on January 7. On January 8, sixteen persons lost their lives in a small dwelling in Boswell, Okla. Seven members of a family died during a night fire in Lincoln Heights, Ohio, on January 11th. In a Kemah, Texas, dwelling, six died, including four children, on January 19. On January 20, six people died in a small dwelling in Ashland, Maine, and on January 30, nine people died in a nursing home fire in Glen Ellyn, Ill.

In case anybody thinks that this was just a particularly bad month chosen to illustrate the seriousness of the problem, following is a list of a similar group of fires that occurred during the month of March 1959. On the 5th of March, seven people died in a hotel fire in Hazelton, Pa., and twenty-one in a dormitory in Wrightsville, Ark. On March 7, six people died in a dwelling fire in Flint, Mich. On March 13, seven died in a dwelling in Easton, Maine. On March 15, eight people died in a dwelling fire in Philadelphia and eleven in a farm dwelling at Cross Hill, S. C. On the 16th, six perished in a dwelling in Superior Village, Wis., and, in Danieltown, Virginia, on March 29, seven died in their home. In two months in just these 18 fires, the life toll was 148, 105 of whom were children! For only 3 of these fires was the cause not definitely established, whereas in 10 of the 18, heater defects were responsible, in 4, careless smoking, and in one, defective wiring. Thus it can be noted that these, as most other fires, were preventable.

Dwelling Inspections Gaining

I have mentioned in previous reviews the campaign being conducted by the International Association of Fire Chiefs to persuade all fire departments throughout the United States and Canada to carry on regular inspections, particularly of dwellings. It is encouraging to note that this campaign appears to be catching on and I believe that more dwellings received fire department inspections in 1959 than in any previous year in history. Millions of dwellings are now getting inspections that were never inspected before. Some of the results of this work are spectacular. Cities that are carrying it on effectively report very substantial reductions in loss of life and in dwelling fires. One of the most significant accomplishments of the year was the increased acceptance of the principle of dwelling inspections by our fire departments.

School Fire Safety Problems

The other major activity, fire-wise, in 1959, resulted from the impact of the Chicago school fire of December 1, 1958 (see January 1959 QUARTERLY or Reprint Q52–8). Throughout the country, school authorities, fire officials, and city officials, generally, took a new, hard look at the safety of their school children. Throughout 1959, the NFPA was flooded with inquiries about school fire safety.

The fire tests conducted in a Los Angeles school building by the Los Angeles Fire Department, with the support of the Educational Facilities Laboratories, Inc., an organization estab-

lished by the Ford Foundation, aroused widespread interest. The complete report of these tests was published by NFPA under the title *Operation School Burning*. It gives significant findings that are bound to influence school construction and protection for years to come. The NFPA Committee on Safety to Life is drafting a revision of the section of the Building Exits Code (NFPA No. 101) on Educational Occupancies as a result of these tests to be submitted for action at the 1960 NFPA Annual Meeting.

A survey of some 2,000 communities undertaken by NFPA and released on the anniversary of the Chicago fire (December 1, 1959) indicated that considerable progress had been made in school fire safety, although much more needs to be done. This survey showed that in some 52,500 public school buildings across the country some fire hazards have been corrected and that major improvements were made in 16,500 schools. For further details on this survey, see pages 193 and 194 of this QUARTERLY. It seems unfortunate that it takes a major fire tragedy to stimulate great progress in fire safety because, after all, there were no really new lessons learned from the tragic Chicago fire itself.

Fire Departments

During the past year the NFPA Fire Service Department published a number of statements focusing attention on the fact that many of our cities of less than 100,000 population were operating fire departments seriously undermanned. These studies have aroused a very large amount of interest in fire department circles. This situation has developed gradually over the years because of the shorter work weeks provided for firemen and the growing expenses encountered by all municipalities. We are hopeful that this dangerous situation will be corrected in the years to come.

In the field of firemen's training continued progress is evident. More firemen than ever before received training during 1959 and for the most part the training programs were better than ever before. There are very few sections throughout the United States and Canada today where a fire department cannot turn to some reliable agency that will provide good training for firemen.

New Air Vehicles — New Problems

While it would be impossible to mention all of the problems that concern fire departments and fire protection authorities, one that is perhaps outstanding in importance is that created by the advent of commercial turbine aircraft and military missiles and space vehicles. This is not a simple problem; it involves enormously large quantities of new and different fuels, changes in the design of airports and changes in the techniques of fire fighting. Various sections of the Aviation Committee of NFPA are struggling with the problem but much remains to be done if fire safety is to accompany these advances in air transportation and our air defense.

Attacks on Other Fire Problems

Many industrial fires caused by careless welding operations led to the creation of an NFPA Committee on Cutting and Welding Practices to provide not only technical but educational material to correct this hazard.

Fire protection authorities and fire departments continue to be concerned about the numerous racketeers that are flourishing in various parts of the country by literally scaring people into purchasing inadequate and substandard fire extinguishing and fire alarm systems for private dwellings, often at excessive

costs. The National Better Business Bureau organization is cooperating in trying to halt these racketeers. An educational article on automatic fire detection for the home is published in this QUARTERLY.

We continue to be concerned about the increasing use of wood shingle roofs, particularly in southern California where, because of climatic conditions, the possibility of a major conflagration exists. An article on this subject appeared in the October 1959 QUARTERLY and has now been reprinted (Q53–8).

1959's New Technical Standards

There were major developments in 1959 in the field of technical standards for fire waste control. Some 60 new and revised standards were adopted at the NFPA Annual Meeting in June, a record number. Those of the most widespread importance are the new National Electrical Code (No. 70), the Building Exits Code (No. 101), the Flammable Liquids Code (No. 30), the Code for Explosives and Blasting Agents (No. 495), the Code for Flammable Anesthetics (No. 56), the Standards on Liquefied Petroleum Gas (No. 58), on Oil Burning Equipment (No. 31), Portable Fire Extinguishers (No. 10), Fire Doors and Windows (No. 80), and the Installation of Gas Appliances and Gas Piping (No. 54). While NFPA codes and standards as presented are purely advisory and are developed through the voluntary service to the Association by appropriate technical people in their respective fields, more and more state, municipal, and other regulatory bodies adopt NFPA standards into laws and ordinances so that more and more of the standards are being used in this way to good effect in reducing fire hazards. There has also been a tremendous increase in the acceptance by industry of NFPA standards in recent years.

New Books on Fire Protection

Two important new books were published in the field of fire protection in 1959. One was a revised edition of the NFPA Inspection Manual which is a guide to fire inspectors by whomever employed. Many thousands of municipal fire inspectors carry this manual with them on their daily inspection rounds. The second was the *Handbook of Industrial Loss Prevention* published by McGraw-Hill Book Company, Inc., and prepared by the staff of the Factory Mutual Engineering Division.

Fire Prevention Contest

The NFPA Fire Prevention Contest for 1959 resulted in Louisville, Kentucky, winning the Grand Award for United States cities, and Vancouver, British Columbia, for Canadian cities. In the various classes of population in the United States the winning cities were Philadelphia; Louisville; Providence; Portland, Maine; Bloomington, Indiana; Martinsville, Virginia; and Glenwood, Iowa. In Canada, class winners were Vancouver; Regina, Saskatchewan; St. Thomas, Ontario; Nelson, British Columbia; Ocean Falls, British Columbia, and Schumacher, Ontario, tied; and Manitouwadge, Ontario.

Year of Progress

Without any question the year of 1959 was a year of developing interest in all phases of fire waste control. The National Fire Protection Association once again broke all previous records for output of material and for over-all activity. This is perhaps the most encouraging development of all because only through a growing knowledge of fire safety and a widening circle of people concerned can we expect to make substantial progress in our still altogether excessive loss of life and destruction of property by fire.

What Progress Since the Chicago School Fire?

By Chester I. Babcock

Manager, NFPA Fire Record Department
Member, Society of Fire Protection Engineers

It is just over a year since fire in a Chicago school took the lives of 92 pupils and three teachers. For anyone who has studied the reports of this fire, it will always be remembered as a tragedy that need not have happened. Certainly the factors responsible for that needless loss of life are well known to QUARTERLY readers: open stairways, delayed discovery, inadequate training in proper emergency procedure, combustible interior finish, poor fire alarm facilities, poor housekeeping, to mention the most important. But conditions such as these do not just exist, they exist because people condone them. So the answer to the question raised on all sides last December, "Why did these pupils and teachers die?" is the same as the "Why?" of every fire disaster — they died because of people, people who because of a lack of awareness of fire hazardous conditions, apathy or what have you, allowed the potentially fatal conditions to exist.

Please do not, however, be under any illusion that these remarks pertain only

Photo No. 1. The stair tower shown has just been added to this school building to provide a second way out from a third-story auditorium. Previously the only exits were two open inside stairways discharging into the first floor.

to the Chicago situation. The Chicago fire might well have happened in any one of thousands of other schools. We all, no doubt, know of one that would have been a likely site in our home town. So every citizen of this country is as responsible for the Chicago school fire as are the people of Chicago. "Chicago" might just as well have been "Your Town."

The lessons are there for all of us to apply. Have we done so? In the year that has elapsed since those 95 lives were lost, has there been any noticeable awakening to the need for improved school fire safety? In other words did the Chicago tragedy have a salutary effect on the thinking of those responsible for our nation's schools?

The Los Angeles School Fire Tests,* one dramatic example of this awakening, were designed to find out what would constitute adequate life safety protection in a multistory school with *open* stairways. Although these tests have not, in my opinion, come up with a satisfactory answer to this question, they have contributed some very valuable information to our knowledge of fire behavior as well as new evidence on performance expectations of certain fire protection devices.

The Los Angeles tests were without doubt the most publicized step forward in school fire safety since the Chicago fire, but equally gratifying and of more immediate benefit to school fire safety has been the elimination of hazardous conditions that existed in thousands of schools across the country December 1, 1958. Firetrap schools still exist, but there is ample evidence to point to the conclusion that in many cities and towns dangerous conditions have been recognized and are being corrected.

*See *Operation School Burning*, available from the NFPA for $4.75 a copy, and the July 1959 QUARTERLY, page 7.

The NFPA last fall conducted a survey of more than 2,000 cities and towns in the United States to find out just what has been and is being done to improve the fire safety of schools since the Chicago fire. The final tabulation of this survey will be found on pages 193–194 of this QUARTERLY. There is already overwhelming evidence that thousands of pupils are attending safer schools today than they were a year ago because of the Chicago fire.

Before presenting some of the evidence that points to this conclusion, here is a simple statement of fact that may have been lost sight of in some quarters during the hysteria following the fire. We know *now* and *have known* since before most of today's school buildings were built how to design and protect a school so that the lives of the pupils and teachers will be safe from fire. Refinements and improvements are needed and undoubtedly will come, but this does not mean that fire protection engineering has been groping for an answer. Practical methods of assuring life safety from fire that have stood the test of time and are based on sound fire protection engineering principles have been available for years.

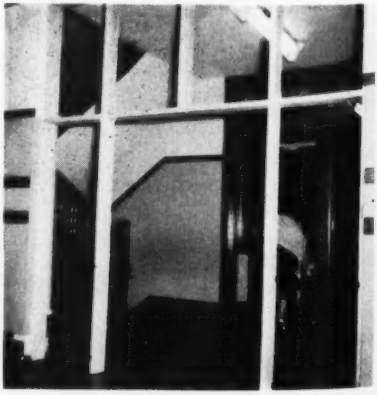


Photo No. 2. Work in progress enclosing an open stairwell.

These principles, which form the basis of the Building Exits Code, include: (1) at least two safe ways out from every occupied part of the building, (2) automatic means for prompt discovery and control of fire, and (3) restriction to a necessary minimum of the amount of material that can burn.

Two Safe Ways Out

To the fire protection engineer, two safe ways out usually means two routes through the building to the outside so constructed that they will be free from smoke, heat, and flames during the period of evacuation — in other words, enclosed corridors and stairways; or if it is impractical to provide two independent inside routes, then a route down the outside of the building via a stair tower or fire escape stairs is called for. In 1-story buildings doors directly to the outside from individual classrooms are often the most practical method of providing an alrernate safe route out.

How is this principle being applied to make our schools safer? Here are a few examples chosen at random from a small group of cities and towns. Most of the schools discussed and illustrated are a few miles from Boston; but from our nationwide survey, I am convinced that these conditions can be duplicated in every section of the country.

For years the fire chief had been trying without success to get school officials to do something about the exits in the building shown in Photo No. 1 (page 181). With two open stairways that discharged into the first story providing the only way out from second-story classrooms as well as from a third-story auditorium occupied at times by as many as 560 persons, there was some reason for his concern. Armed with the report of the Chicago fire, he has finally been able to get work started on necessary improvements. A stair tower has just been erected to provide an additional exit from the third-story auditorium.

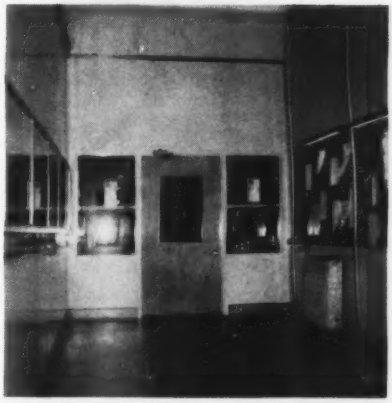


Photo No. 3. A new stairway enclosure.

Photo No. 2 shows work in progress on the enclosure of the two open stairways.

Speaking of stairway enclosures, it is most encouraging to learn that so many of the unprotected openings in the architectural monstrosities of the past are at last being enclosed. Photo No. 3 shows an enclosure with doorway, beyond which is one of the two stairways in an old 300-foot-long, 4-story brick, wood-joist building. Six months before this picture was taken, these stairways, which were the only routes out of the building, were open. Now they are enclosed.

Photo No. 4 (page 184) was taken from the grade level landing in the open rear stairwell of the north wing of Our Lady of the Angels School, Chicago.

The evidence indicated that the fire originated in an accumulation of trash and other combustible material at the foot of this stairway. A closed fire door at the first floor landing kept the fire from entering the first story. There was no enclosure at the entrance on the second story where those who died were located.

Chicago Sun-Times

Photo No. 4. Chicago's fatal stairway.

Following the Chicago fire, a 2-story grade school was closed by the fire department because of hazardous conditions, including overloaded wiring and unsafe exits. Faced with the choice of building a new school or placing this one in a reasonably safe condition, the townspeople decided they could live with the old building if their children could live in it. Inside stairways were enclosed (see Photo No. 5), fire escapes were added, the building was completely rewired and consequently is now back in business.

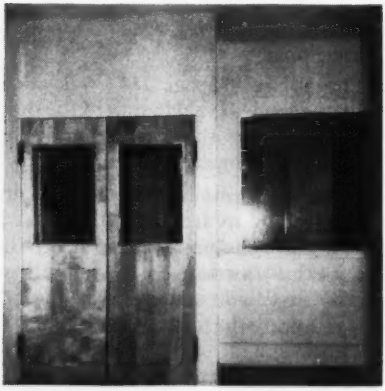


Photo No. 5. Improvement in an old school.

The schools discussed previously were architectural monstrosities of the past. Photo No. 6 was taken in an architectural monstrosity of today. When this brand-new school was turned over to the school board, stairways between the first and second stories were open. As you can see, the situation has been corrected.

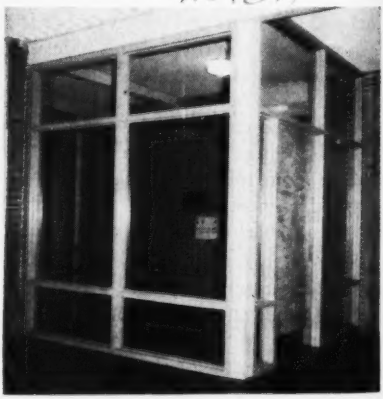


Photo No. 6. Improvement in a new school.

Sometimes there appears to be no practical way to enclose stairways. Photo No. 7 shows the ends of two wings of a large high school. With no practical way of enclosing stairways that extended up through the center of each wing, it was decided to remove the stairways entirely, enclose the floor openings and require use of stairways in the communicating main building. Outside fire escapes were added to the ends of the wings for emergency use, and in addition the entire building was sprinklered.

There is no need to comment on the value of panic hardware for exterior

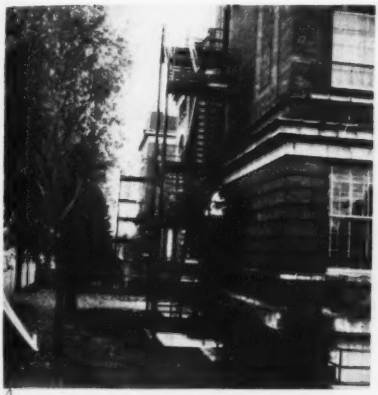


Photo No. 7. Outside escapes being added.

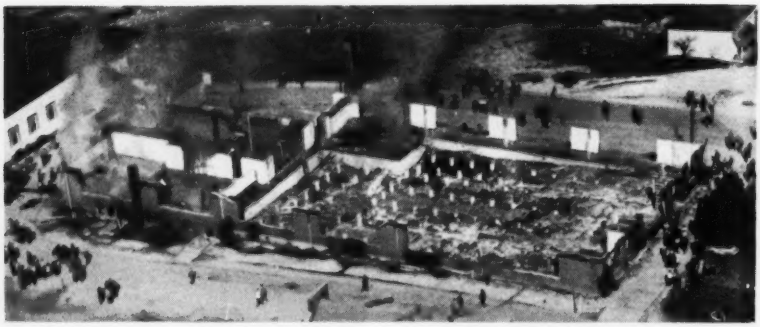
Photo No. 8. Panic hardware added.

doors in a pathway to safety, but it is shocking how many instances were reported, such as the one in Photo No. 8, where panic hardware was missing until the general awakening to school fire safety following the Chicago fire.

So far we have been discussing primarily solutions to problems with exits from upper stories. The problem of first-story evacuation has not been overlooked just because the deaths at Chicago involved occupants of second-story classes. The Cheektowaga, N. Y. (see Photo No. 9), and Mount Airy, N. C. (see Photo No. 10), schools are notorious examples of 1-story death traps. The stairway in Photo No. 11 was one of two added last summer to give the occupants of first-story classrooms a direct exit to outside. A year ago the only way out of these rooms was a common hallway.

I. Russell Sorgi

Photo No. 9. Fifteen children lost their lives in this one-story, school building in Cheektowaga, N. Y., on March 21, 1954. The fire originated in a teachers' workroom where stage properties were stored, flashed into the corridor barring escape via that corridor for 31 pupils and 3 adults in a room diagonally across the corridor. For full details, see April 1954 QUARTERLY or Reprint Q47–12.



United Press Photo

Photo No. 10. This school near Mount Airy, N. C., burned on Feb. 22, 1957, and cost the lives of one 9-year-old crippled boy and his heroic teacher who tried to save him. Classrooms entered into a central auditorium where the fire started, forcing escape via windows.

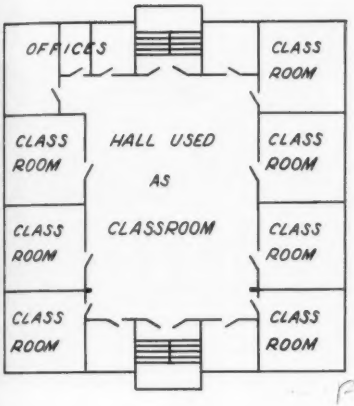
No longer will the occupants of the basement classroom in Photo No. 12 have to go through the basement, up stairs and out the front door in case of fire. By the conversion of a window to a door and the addition of a flight of steps, these children can now go outside by a direct, short route.

In the opinion of the fire chief, the 1-story school in Photo No. 13 was not a safe place for children to be due to the fact that the only exit route from classrooms was through a central hallway. The school will be reopened when and if doorways directly to the outside are added from individual classrooms.

As you will note from the diagram in Figure A, the second-story classrooms of another school emptied into a large central hall. This hall contained tables and chairs and was itself in fact a schoolroom. School and fire officials lived with this dangerous condition until the Chicago fire, when they decided something had to be done. Their solution, I think, was rather ingenious. Looking at Figure B, you will see that it consisted of the creation of a corridor at one end of the hall from which there was direct access to one of the two enclosed stairways, and then, so that pupils could get to this corridor

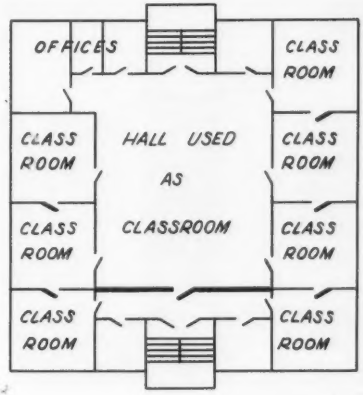
Photo No. 11. New exit from classroom.

Photo No. 12. Basement room has new exit.



BEFORE

Figure A. Only way out through central hall.



AFTER

Figure B. Improved exits facilities.

without going through the central hall, doors were installed between classrooms.

Photo No. 14 shows a view from the central hall showing the newly built wall. The new corridor is beyond the wall.

One of the doorways that were cut between classrooms is shown in Photo No. 15, page 188.

So much for examples of improvements in exit facilities.

Discovery and Control

Prompt discovery and control of fire, where life safety is at stake, is the second principle of school fire safety. This means to the fire protection engineer automatic sprinklers, automatic fire detection systems, and automatic fire department notification. Such protection, although not a substitute for required exits, is a very desirable supplement. It provides additional time for the use of the exits and assures prompt fire control measures.

Photo No. 13. Closed for lack of exits.

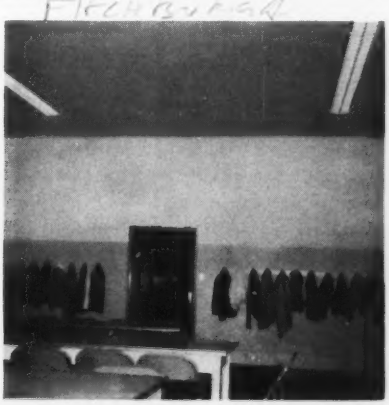


Photo No. 14. Door from central hall to corridor.

Photo No. 15. Door between classrooms.

Photo No. 17. Another newly sprinklered school.

The value of automatic sprinklers as a life safety device was confirmed in the Los Angeles School Fire Tests where it was shown that with a complete automatic sprinkler system and a sprinkler operating directly on the test fire, low temperatures were maintained throughout the building and build-up of smoke and irritating gases was reduced.

What would you do with the monument in Photo No. 16 to some long-departed architect, short of closing it up? Although the fire chief was assured that this building was soon to be replaced, his recommendation of last March that the building be completely sprinklered prevailed. It was felt that this protection in conjunction with outside fire escapes from individual rooms would be the only practical answer for this 3-story building.

Photo No. 17 shows a parochial school just completely sprinklered on the advice of the fire chief. In addition to the increased life safety represented by these sprinklers, they also are a guarantee that the building in all likelihood will be available for use as long as

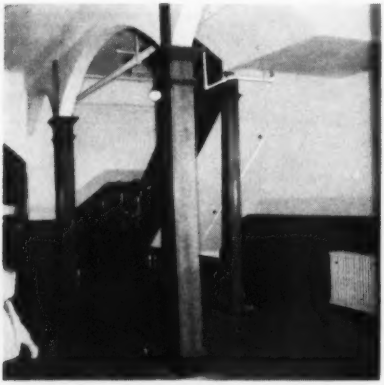


Photo No. 16. Note sprinklers, please.

Photo No. 18. 2,000 students safer!

it is wanted — $8,000 well spent! Other improvements included rehanging of stairway enclosure doors so that they would close properly. It was rather discouraging, shall we say, to find one of these doors blocked open, ostensibly for the convenience of the janitor.

On Photo No. 18 is a sight that might please many readers. It shows the 8-inch supply main, sprinkler control valves, and risers for complete sprinkler protection being installed in a high school housing 2,000 students.

Photo No. 19. Direct alarm to fire dept.

Another valuable life safety tool being introduced in schools because of the Chicago fire experience is the automatic fire detection system. Some misguided people have installed automatic detection equipment under the illusion that this device alone will convert an open stairway firetrap school into a safe place for children. When coverage is complete and the system is wired to notify simultaneously building occupants and the fire department, such systems are a valuable *supplement* to proper exit facilities in that they give the alarm for building evacuation before the fire has made much headway. They also eliminate that old bugaboo of the fire department — delayed notification.

The grade school in Photo No. 19 offers an example of how automatic detection protection should be installed. Detectors have been installed in every part of the building, including closets. The system has been connected to the city fire alarm system through a connection at the master box shown in the photo and, of course, is arranged to actuate the building fire alarm gong. When improvements in stairway enclosures are completed, this school should be a safe place for children to be.

So far we have been looking only at examples of *automatic* fire protection. *Manual* means of alerting the building occupants and the fire department are also a vital part of the life safety facilities of a school. Every school has no doubt a manual alarm system of sorts, but with the experience of Chicago as a backdrop, town after town has taken a second look at its alarm facilities. More often than not, improvements were called for.

Photo No. 20. Connection to city FA system.

A year ago the fire alarm system in the school in Photo No. 20 consisted of a special coded signal on the class change bell operated from the principal's office. Fire drill signals were

often confused with class change signals. Now manual pull boxes are available throughout the building, the system has been connected to the city fire alarm system through the master box shown in the picture and distinctive horns have replaced the old school bell.

In Photo No. 21 we see a brand-new elementary school in its first semester of operation — modern in every way except fire safety. Yes, that is combustible finish on the walls and ceiling, and until recently the boiler room was lined with polystyrene foam as a sound deadener, just to mention a few of the interesting fire problems built into this structure. But what should be particularly noticed is the school fire alarm bell mounted on the wall. There were several of these little bells in the building, but their sound was so weak that they could not be heard in some of the classrooms. During one fire drill two classes did not leave because no one heard the alarm. This situation is being corrected, but unfortunately there are no immediate prospects of solving the major problem at this new school — the excessive amount of combustible interior finish.

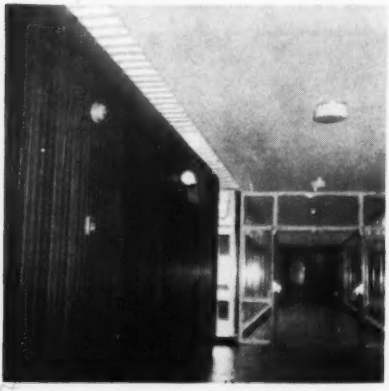


Photo No. 21. Alarm bells inadequate.

Photo No. 22. Alarms had no power supply.

When the junior high school shown in Photo No. 22 was built 20 years ago, a manual fire alarm system with numerous well-marked and easily accessible pull boxes had been installed. "Fine, but why not tie in this system to the public fire alarm circuit?" the chief asked himself one day last summer. Imagine his reaction when the electricians assigned to make the connection reported their discovery that the local system had never been connected to a power supply. You think the chances of something like this happening are about one in a million? Worth mentioning is a discovery made by a fire protection engineer this summer while making a special survey of a school system about 15 miles from the previously mentioned school. His joy on discovering a sprinkler system in the high school quickly disappeared when he got to the basement and found that there was no connection between the main control valve and the water system. This condition had existed since 1932!

These few examples are sufficient to indicate that definite progress has been made since December 1, 1958, to apply

the principle of prompt discovery and fire control to school buildings.

Limitation of Combustible Material

You will recall that limitation of material available to burn was the third principle of school building fire safety. The ways in which this principle can be applied are obvious — regular and frequent rubbish removal, elimination of stored materials such as old furniture and obsolete records, removal of nonessential combustible interior finish, application of fire retardant coating to finishes that must stay, and segregation of hazardous areas. As you can imagine, just about every school system has been active in applying this principle to some extent. Here is one example from the record.

In one city identical improvements had been scheduled for two identical schools. When Photos No. 23, 24, and 25 were taken, work had been completed in one and was about to be started in the other. The schools therefore presented a good "before and after" comparison.

Photo No. 23. Janitor's room before cleanup.

Photo No. 24. Unnecessary fuel for a fire.

Photo No. 23, the janitor's room, and Photo No. 24, a typical corner of the basement, show two examples in the still-to-be-corrected building.

In Photo No. 25 we see the completed job. The boiler and janitor rooms are of fire-resistive construction and cut off by fire doors. The rest of the basement is absolutely spotless.

Conclusion

So there is the evidence — a small sampling, to be sure, but enough to permit the conclusion that there has been a most remarkable awakening to the need for better fire safety in our schools during the past year. The results are encouraging, but let no one be under the illusion that the job is done. Resistance is still strong in many communities to spending money on old schools or to giving careful attention to life safety features of new schools, on the false assumption that because a building is new it must be safe. Oh, that this were true!

Yes, more still remains to be done and every day that puts the Chicago experi-

FITCH

Photo No. 25. After the cleanup mentioned in the text.

ence further into the background of people's thinking makes the job that much harder. The improvements we have sampled herein were accomplished primarily because the public and their fire and school officials saw the report of the Chicago school fire as the valuable tool it was meant to be and used it to get results.

In the year following the Chicago fire, major improvements in life safety were made in an estimated 16,500 school buildings in the United States.* Whether these schools maintain their level of fire safety, however, will depend on the future attitude of those responsible for their safety. Only by continued alertness to all phases of the fire safety of these buildings, including a regular maintenance program for fire protection equipment, can there be any assurance that today's protection will be available tomorrow.

It is still not too late to remove school firetraps once and for all from the American scene. Everyone has a responsibility to see to it that there are none of these in his town. Only when all have been eliminated can we say that those 95 children and teachers who died in Chicago last year did not die in vain!

*See "Improvements in School Fire Protection," this issue of the QUARTERLY, pages 193 and 194.

Improvements in School Fire Protection

A survey conducted by the National Fire Protection Association.

In the weeks immediately following the Chicago school fire in which 95 lives were lost, it became apparent that many parents and fire and school officials were determined that the Chicago experience would not be repeated in their communities.

To what extent was this concern translated into action? It is well known that major improvements in fire safety usually follow large loss of life fires. The Iroquois Theater fire, for example, stimulated widespread activity to improve the fire safety of theaters; the Triangle Shirtwaist fire was responsible for major improvements in factory fire safety; and the Cocoanut Grove fire for improved life safety conditions in night clubs. As an aftermath of the Chicago fire has there been a noticeable improvement in the fire safety of schools throughout the United States?

In an effort to find out to what extent the level of school fire safety has been raised in the year following the Chicago fire, the NFPA asked more than 2,000 fire departments of representative U. S. cities, towns, and rural areas to report on progress in their communities. Based on the results of this survey, estimates of over-all U. S. school fire progress have been made.

The results of the survey are encouraging. Because of major improvements made in 16,500 school buildings, 4,500,000 more children are today attending schools that are significantly safer from fire than was the case a year ago. Another 9,700,000 children are attending 36,000 public schools in which some life hazards have been reduced during the past 12 months. The survey further indicates that 68 per cent of all U. S. communities have made physical improvements. Nearly every community has acted on such matters as frequent and better exit drills, tighter control of waste disposal, inspections and proper storage of combustible supplies.

While more than 17,000,000 public school children are now being taught under reasonably fire-safe conditions, the survey indicates that no action was taken on needed improvements in about 30,000 schools housing 8,250,000 children. Added to these are the 9,700,000 attending 36,000 schools where something but not enough has been done to bring the schools up to minimum life safety standards. In these two groups are almost 18,000,000 children still needlessly exposed to fire hazards.

The accompanying Table I, based on the NFPA survey, presents estimates of the number of major and other physical improvements in public school building fire safety in the United States made between December 1, 1958, and December 1, 1959.

In addition to the improvements in Table I, pertaining to individual buildings, the following procedural and structural changes were frequently mentioned in the survey as applying to entire school systems.

Training for Fire Emergency

Teacher training by fire department.

Annual custodian training by fire department.

Sparky fire departments and other children's programs started.

Custodians made members of fire department.

Monthly custodian and teacher safety letter inaugurated.

Fire Inspections

Daily inspections by custodians of exits and rubbish disposal.

Complete monthly inspections by trained custodians.

Complete quarterly fire department inspections.

Custodians required to make immediate corrections of certain fire hazardous conditions and to report others.

Fire Exit Drills

Monthly unannounced system of fire drills instituted.

At least one fire department response annually.

Blocked exit drills held.

Room searchers and class leaders appointed.

Community Cooperation and Action

Greater cooperation and communication between fire and school departments.

School safety committees established with representatives of fire department, superintendent's staff, teaching staff, P.T.A., police department, and other interested groups.

Fire prevention, building, and building exits codes adopted.

Housekeeping Improvements

Storage of combustible materials limited.

Removal and disposal of rubbish improved.

Physical Improvements (not listed in Table I)

Exit signs and lights added.

Fire extinguishers and standpipe hoses installed.

Fire department maintenance of fire equipment instituted.

Smoke barriers installed in halls.

Transoms blocked up or wired glass installed.

TABLE I.

Major Improvements in Fire Safety of U. S. Public School Buildings

(Estimates of Physical Improvements Made Dec. 1, 1958 – Dec. 1, 1959)

	No. of Buildings Improved
Exits	
All stairways fully enclosed	6,100
Interior exit routes added (Doors between rooms, stair towers, etc.)	3,700
Exterior exit routes added (Doors directly outside, fire escape stairs, etc.)	5,700
Panic hardware added	13,800
Automatic Sprinkler Systems	
Complete systems installed	1,100
Partial systems installed	1,700
Automatic Detection Systems	
Complete systems installed	1,200
Partial systems installed	2,200
Combustible Interior Finish	
Finish removed	3,000
Finish coated with fire retardant paint	3,600
Manual Alarm Systems	
Interior systems improved	24,600
Public fire alarm boxes installed within 100 ft. of building	2,800
Alarm and sprinkler systems connected to the fire department	5,900

Explosives Truck Blast in Roseburg

Wide World

The 52-foot-wide crater marks the spot, on Pine Street between Washington Avenue (right) and Oak Avenue (left), where a truck loaded with explosives and blasting agents had been parked for the night in a downtown section of the peaceful Oregon city of Roseburg.

Two tons of explosives and 4½ tons of blasting agents, loaded on a parked truck, detonated in Roseburg, Oregon, killing thirteen people and injuring 125. Heat from a fire in a building about 4 feet from the parked truck initiated the explosion shortly after 1 A.M. on Friday morning, August 7, 1959. Over $10,000,000 in property damage resulted, largely in a roughly circular area (approximately 0.365 sq. miles) within about 1,800 ft. of the explosion site.

A study of the disaster breaks down into three parts: (1) the events leading up to the explosion, (2) the explosion, and (3) the aftermath.

Events Leading up to the Explosion

Roseburg, the county seat of Douglas County, is nestled in southwest Oregon between the Cascade Mountains and the Coast Range. It has a population of approximately 13,000 and covers an area of 4.15 square miles. Joining with lumber in the economic support of the

We wish to acknowledge the help of the following individuals and departments in the preparation of this report: Eldon Winkley, Chief Deputy State Fire Marshal of Oregon; Donald Starmer, Chief of the Roseburg Fire Department; Carl A. Weers, Assistant Chief Engineer of the National Board of Fire Underwriters; and the Interstate Commerce Commission.

city are mining, agriculture, and the tourist trade. Roseburg is one of Oregon's older cities, having been incorporated in 1872, and is currently under a city-manager form of government.

At the time of the blast the city had no fire code. Mercantile buildings were mostly brick, wood-joisted buildings separated from one another by fire walls. About one-half of the buildings in the area of the explosion were of this construction. The others were of wood or unprotected metal frame.

The City Fire Protection

The central fire station, located in City Hall, was equipped with two 1,000-gpm pumpers, one 500-gpm pumper, and a salvage truck. Across the Umpqua River, which divides the city, was another (west) fire station which housed a 500-gpm pumper.

The sixteen paid fire fighters each worked two 24-hour shifts every 5 days (67 hr. week). Thus the main station was manned by only an officer and either two or three men, one of whom remained behind on alarms to act as dispatcher until relieved. The west station was manned by two men.

The gravity flow water system is fed by four reservoirs of 3,400,000 gallons total capacity. The water is distributed mainly through 6-inch mains with static pressure of 85 to 100 psi.

The Douglas County mutual aid response program was in full operation early in 1959. The program had been established in 1958 with the assistance of the Oregon State Fire Marshal's office.

On all building fires in Roseburg a general alarm was sounded on two separated sirens. At the sound of the alarm all off-duty men and fifteen "call" men telephoned the station dispatcher. They were given the location of the fire to which they responded promptly. The first two off-duty paid men to call in were told to report to the main station and be ready to respond with another pumper if needed.

The Explosives Truck

A 2½-ton, 1959-model, aluminum van-type truck with a canvas tarpaulin as a rear cover was parked on Pine Street about 4 feet from Garretsen Building Supply Co., a 60 ft. by 205 ft., 1- and 3-story masonry and wood building.

The truck was loaded with eighty 50-pound boxes (4,000 pounds) of 2-inch by 16-inch sticks of 40 per cent dynamite (40 per cent nitroglycerin) and 180 50-pound, 3-ply bags (9,000 pounds) of a blasting agent.

Most blasting agents are an admixture of ammonium nitrate with some combustible material, and are not, and should not be referred to as ammonium nitrate.* To differentiate blasting agents from commercial explosives, the Interstate Commerce Commission applies the term "nitro-carbo-nitrate" to commercially prepared blasting agents packaged and shipped in accordance with I.C.C. regulations. The blasting agent involved in this explosion was a mixture of ammonium nitrate, ground walnut shells and diesel oil, which falls under the I.C.C. shipping regulations for nitro-carbo-nitrates as described above. Nitro-carbo-nitrates are classified as an *Oxidizing Material* by the I.C.C., and dynamite is classified under "High Explosives" as *Class A Explosives*. Fertilizer-grade ammonium nitrate is classified by the I.C.C. as an *Oxidizing Material*.

A blasting agent is much more sensitive to explosive decomposition initiated by an explosive than are pure or

*For information on the burning characteristics of pure and fertilizer grades of ammonium nitrate, see article starting on page 217 of this QUARTERLY.

fertilizer grades of ammonium nitrate. On the other hand blasting agents are less sensitive than commercial explosives in that something stronger than a No. 8 Test Blasting Cap is required to initiate detonation.

Undoubtedly the explosion of the 4,000 pounds of dynamite on the truck was initiated by the heat from the exposure fire, and this explosion instantly initiated the detonation of the blasting agent.

Whether the blasting agent would eventually have been detonated by the heat of the exposing fire is open to conjecture. In the NFPA Code for the Manufacture, Transportation, Storage and Use of Explosives and Blasting Agents (No. 495), there are specific fire prevention requirements for warehouses in which blasting agents are stored.

The red truck was marked by "Explosives" signs on front, rear, and sides. The 5-inch letters of these signs were painted in cream-colored fluorescent paint on a contrasting red background. The driver had a record of 31 years of truck operation without an accident or even a traffic violation. He parked his truck near the Garretsen building. He claims that he received permission from someone in the building to park where he did. He knew he should not leave his truck "unattended,"* but says he was told by the unidentified person that a merchant's patrolman checked the area every hour. Thus he assumed the truck was "attended." He checked into a nearby hotel at 8:34 P.M. on August 6, but reported being unable to sleep. About 10:30 P.M. he went out and checked the truck. He walked around it, finding everything in order. He returned to the hotel and finally fell asleep.

*He evidently did not know that he could not leave the truck here even if attended as noted in the next section "Regulations."

Regulations

The truck, having been loaded in Washington for delivery in Oregon, was engaged in interstate commerce and was thus subject to the regulations of the Interstate Commerce Commission. These regulations, published in the Code of Federal Regulations Title 49 — Transportation. Part 197 — Transportation of Explosives and Other Dangerous Articles by Motor Vehicle, state in Paragraph 197.1:

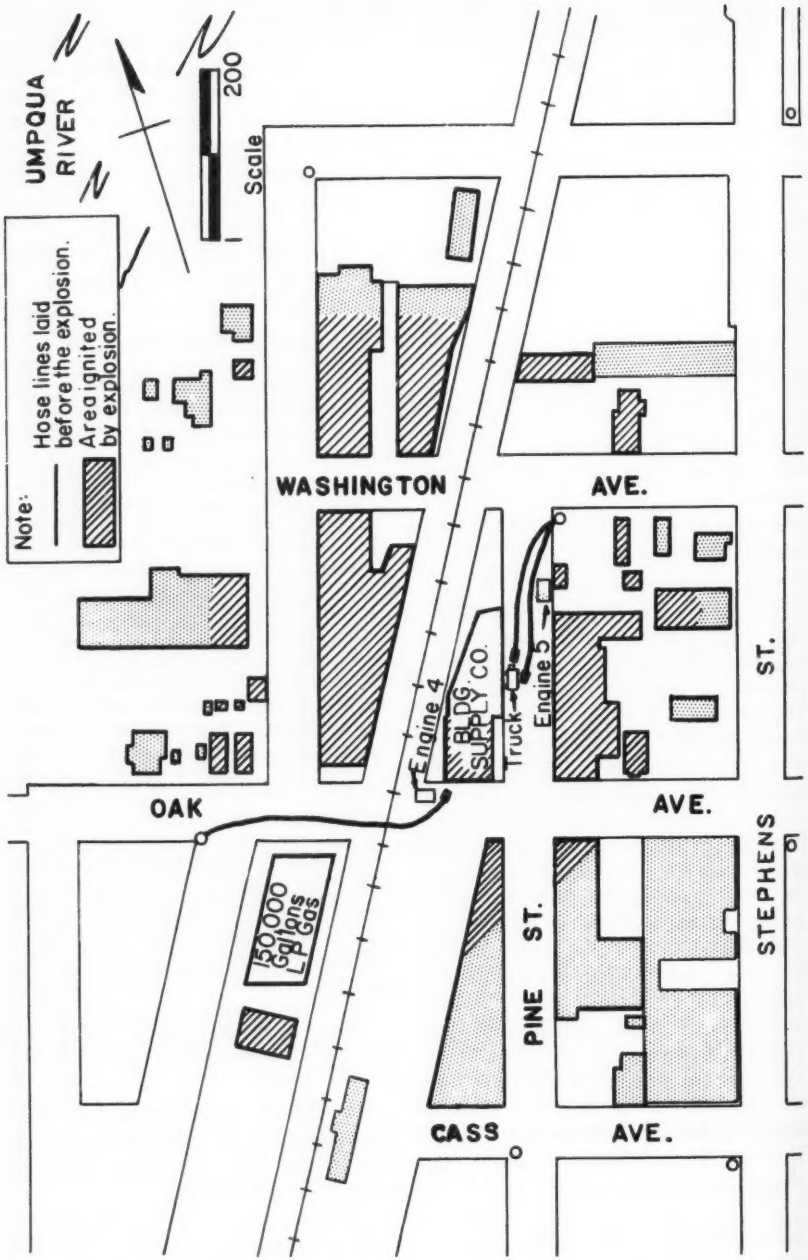
> "(b) *Motor vehicles not to be left unattended at any time.* Motor vehicles transporting Class A or Class B explosives shall not be left unattended at any time during the course of transportation. . . ."
>
> "(c) *Avoidance of congested places.* Motor vehicles transporting explosives and other dangerous articles shall be driven as to avoid, so far as practicable, and, where feasible, by prearrangement of routes, congested thoroughfares, places where crowds are assembled, street car tracks, tunnels, viaducts, and dangerous crossings."
>
> "(h) *Parking in congested places.* Except where the necessities of the operation make impracticable the application of this paragraph, no motor vehicle transporting any Class A or Class B explosives shall be parked, even though attended, on any public street adjacent to or in proximity of any building, or place where people work, congregate or assemble."

Oregon State regulations for the intrastate transportation of explosives are controlled by the Oregon Public Utilities Commission. This Commission adopts the I.C.C. regulations as the state law.

There were no city regulations for the transportation of explosives at the time of the fire.

The NFPA Code for the Manufacture, Transportation, Storage and Use of Explosives and Blasting Agents (No. 495) states in Paragraph 432:

> "Except under emergency conditions, no vehicle transporting explosives shall be parked before reaching its destination, even


UMPQUA RIVER
N
N
200
Scale
Note:
Hose lines laid before the explosion.
Area ignited by explosion.
WASHINGTON AVE.
OAK AVE.
PINE ST.
CASS AVE.
STEPHENS ST.
BLDG. SUPPLY CO.
Engine 4
Truck
Engine 5
150,000 Gallons LP Gas

though attended, on any public street adjacent to or in proximity to any bridge, tunnel, dwelling, building, or place where people work, congregate, or assemble."

and in Paragraph 434:

"Vehicles transporting explosives shall avoid congested areas and heavy traffic. Where routes through congested areas have been designated by local authorities such routes shall be followed."

For an interesting discussion of the problems of enforcement of federal legislation on the transportation of explosives see the article "State Interests in Explosives Transportation," by Captain (now Major) Carroll E. Shaw, Connecticut State Fire Marshal, published in the January 1957 NFPA QUARTERLY, pages 172–175.

The Fire

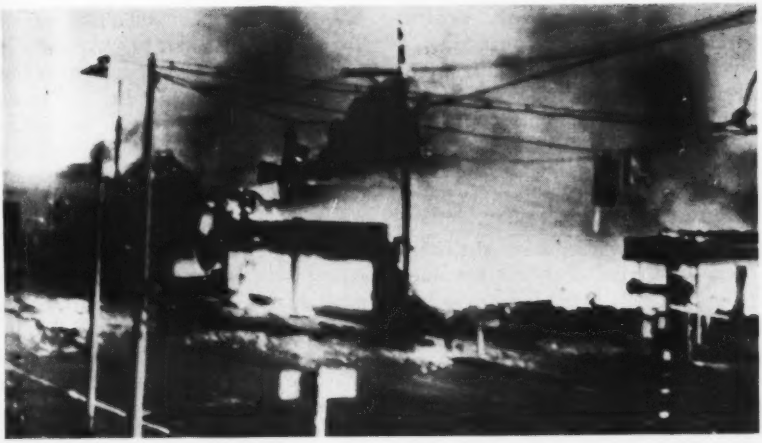
Dennis Tandy (17) was driving west up Oak Avenue between 12:30 and 1 A.M. in his little Fiat car after his shift at one of the local veneer mills. He was on his way along Oak Avenue to pick up his wife at her father's house. The weather was pleasant. Temperature was 72° F, the wind 8 mph, and humidity 50 per cent. He evidently saw nothing unusual at this time since he passed the intersection at Oak Avenue and Pine Street and proceeded on his errand. He was returning home with his wife along the same route shortly thereafter when something did catch his eye as they passed Pine Street. Backing up to the intersection, he wheeled into Pine Street and hopped out of the car when he saw flames about 50 to 60 feet behind the explosives truck and near the wooden wall of the building supply company in what appeared to Mrs. Tandy as trash barrels. The fire inside the building was evidently not visible to Mrs. Tandy at this moment. Dennis told his wife to go and call the fire department while he tried to do something about the fire. Mrs. Tandy drove to an all-night service station one block away, gave the alarm to the attendant and then returned to the scene. The attendant called the fire department (1:05 A.M.). On Mrs. Tandy's return the 1-story section of the building was heavily involved and flames were leaping from the building. Dennis told his wife to get in the car and drive away.

Figure 1. This drawing shows the location of Roseburg fire equipment and hose lines before the explosives truck blast. The gray area indicates buildings. The fire originated in the building supply company. The crosshatching shows the area of buildings ignited by the explosion. The Umpqua River is located a few hundred feet west on Oak Avenue.

While Mrs. Tandy had been returning from giving the alarm, the Roseburg Fire Department swung into action. Assistant Chief Roy McFarland and Fireman Lyle Wescott were approaching the fire in one 1,000-gpm pumper, Engine 5. The other fire fighter on duty in the main station, serving as dispatcher, received Chief McFarland's radio message that this was a "burner" inside the Building Supply Co. A general alarm was sounded. Engine 4 from the west station responded with the two paid men and a station sleeper while Engine 5 laid a line to, and another from, a nearby hydrant and set up operations on the Pine Street side of the building. Fire fighter Wescott discovered that the explosives truck (not yet identified) parked on the street, did not offer him much protection from the terrific heat of the building fire. As he was forced back, he felt burning sensations under his black turnout coat and liner, and noticed flesh slipping off his hands. He was placed in a police cruiser and driven to the hospital.

Engine 4 had now arrived and laid a line on the Oak Avenue side of the building as arranged in a prefire plan.

UMPQUA RIVER
N
N
N
200
Scale
Note:
Hose lines laid for confinement.
Area destroyed in fire.
STEPHENS ST.
WASHINGTON AVE.
BLDG. SUPPLY CO.
ST.
OAK AVE.
150,000 Gallons Gas
PINE
CASS AVE.
Engine 4 Relocated



United Press International

A view south on Stephens Street from the intersection with Washington Avenue during the fire fighting.

This move was planned to limit fire-spread in the westerly direction and protect the 150,000-gallon aboveground LP-Gas bulk plant diagonally across Oak Avenue and one block distant. There are indications that Assistant Chief McFarland had realized only moments before the explosion that the truck on Pine Street contained explosives. He had evidently just given the order for evacuation of the area.

As only two men were provided by the city to respond on first alarm with a fully equipped 1,000-gpm pumper, it is not strange that the extended time it took them to lay two hose lines delayed the identification of the explosives truck. Likewise, it is not strange that since each man (one a chief officer) was next fully occupied handling a hose line at close to 80-pounds pressure, that the truck went further unidentified. Remember, the heat was so intense that one fire fighter had already been burned under his protective clothing, therefore it is not strange that the few, lightly clothed civilians helping on the hose lines were unable to set up a water curtain to protect the explosives truck.

Figure 2. Shown are the locations of hose lines laid to confine the explosion-caused fire and the area eventually destroyed by the fire.

The Explosion

The exposed truck was heated to the point where, at 1:14 A.M., its load of explosives and blasting agent detonated. The explosion opened a crater 20 feet deep and 52 feet in diameter. The twenty-eight surrounding blocks received extensive structural damage. The ground shook 17 miles away, a "loud thud" was heard 30 miles away and a "big flash" lighted up the sky so as to be visible 45 miles away.

Assistant Chief McFarland, Dennis Tandy, a police officer who had just arrived, civilians aiding them, and several spectators were killed. Pieces of the explosives truck were dispersed over a wide area; for instance a twisted axle was found 3½ blocks away. Engine 5 was permanently disabled. Engine 4 was damaged but still usable. The blast ignited several buildings as shown in Figure 1.

Already responding with another 1,000-gpm pumper from the main station was the department training officer and Senior Lieutenant Donald Starmer; with him was a fire fighter who had responded to the fire but was ineffective without his protective clothing. He had returned to the main station to pick up his coat, boots, and helmet. Lt. Starmer radioed the report of the chaos he found on arrival and was informed that Department Chief Mills, who had had two previous heart attacks, had just suffered another one and could not respond. Lt. Starmer notified the dispatcher that he was assuming command and asked for all available mutual aid help.

The men of Engine 4 picked themselves up off Oak Avenue. Injured and shaken by the blast, they struggled to relocate their line so as to protect the LP-Gas bulk plant.

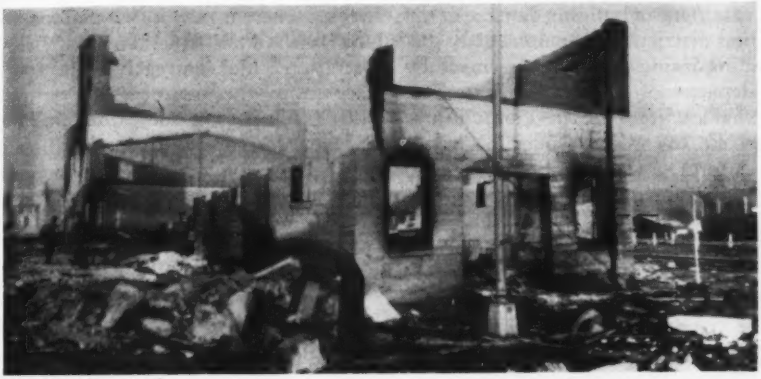
Lt. Starmer spent some time with his engine until he had it adequately located and set up to turn over to another man. He then took command of the over-all placement of companies. He assigned officers to each side of the spreading fire and located mutual aid companies to provide confinement of the fire. One Roseburg engine responded to two grass fires set by flying brands several blocks down wind from the major fire. The men on this engine found the fires extinguished by civilians on arrival. In at least 6 cases after this, people were told that they had to handle the fires themselves, as no equipment was available to respond. By 2:25 A.M. the fire was surrounded and by 3 A.M. was under control. The extent of damage is shown on Figure 2.

The Aftermath

Following the extinguishment of the fire a large problem remained. What

Paul Jenkins

Looking north past explosion-damaged Roseburg Engine 4 to the intersection of Pine Street and Cass Avenue. Engine 4 was relocated after the explosion to this position and played a vital part in preventing fire spread to the south from the involved building, a flour mill, shown above.



United Press International

This view southwest across the intersection of Pine Street and Oak Avenue shows the heavy explosion damage to the large triangular flour mill located there. Part of the LP-Gas bulk plant can be seen to the extreme right. It was at this intersection that Dennis Tandy first discovered the fire.

buildings were safe? Was the underground gas or water piping damaged? How could the necessary public safety be provided with a major part of the downtown area destroyed?

The State Police had already set up road blocks at all major highway entrances to the city to prevent the entrance of spectators. The National Guard mobilized and completely sealed off the stricken area. The Roseburg police force was given the task of preparing passes for those allowed in the sealed area. All electricity to the damaged area was shut off. A valve was closed at the Oak Avenue LP-Gas installation shutting down all gas service in the city.

On Sunday afternoon (two days after the explosion) the first of many daily coordination meetings was held in the city manager's office. Represented were fire, police, military, and engineering officials of the state and the city. The decision was made at this meeting to open the sealed area, building by building, working from the outside in as buildings were inspected and certified safe. A call for additional inspection personnel was made with the result that enough building, boiler, elevator, electrical, and flue inspectors were obtained from other Oregon cities. As the restricted area shrunk in size, the utility companies reported their plans for the reopening of their services. Each plan was reviewed and either approved or revised to be acceptable. Each section of the gas piping underwent a pressure test and was either certified acceptable or was replaced.

Until LP-Gas distribution mains within the damaged area could be repaired, 25-gallon or smaller capacity LP-Gas containers were allowed at certain occupancies under strict controls. Each installation was also subject to all provisions of "The Standard for the Storage and Handling of Liquefied Petroleum Gases" (NFPA No. 58).

The electrical inspectors working with electricians checked each building within the area. The utility company energized or isolated the properties at the inspectors' direction.

By August 15, 1959 (8 days following the explosion), practically all inspections were completed and the utility systems restored to service in those areas found to be safe.

A catalogue of building damage in the business district and the immediate surrounding residential area was made by the deputies of the Oregon State Fire Marshal's office. Of the 256 buildings inspected, 185 were masonry, 53 wooden, 15 brick, and 3 metal. Of these 20 suffered complete structural damage, 90 heavy structural damage and 146 light structural damage. Glass damage was total in 126 of these buildings, heavy in 93 and light in only 37.

The city of Roseburg has since adopted the "Code for the Manufacture, Transportation, Storage and Use of Explosives and Blasting Agents" (NFPA No. 495), and is preparing for adoption of a fire code. Changes have been made in the telephone and radio systems to provide for police department dispatching of fire equipment. The fire department has been reorganized, as the fire fighters have agreed to work a 72-hour week. There is now a two platoon system with a full-time fire marshal, a battalion chief on each shift and a captain in the west station on each shift. A new fire and police building is being designed and additional training being provided. Long range plans have been made to upgrade the town from Class 5 to Class 4 protection.

Post-Mortem

Upon Chief Mills's resignation for ill health on August 14, 1959, Lt. Starmer was appointed acting chief. The following post-mortem is a direct quote from Chief Starmer's report to the NFPA. It is included here because of its tremendous importance and uniqueness. His actions, those of the late Asst. Chief McFarland, the men of Engine 4, and the other fire fighters reflect the highest credit on the American Fire Service.

Paul Jenkins

A view north past trucks parked in the debris of the Coca-Cola plant, past the intersection of Pine Street and Washington Avenue, past the railroad and debris of the Farmers Bureau to the quiet hills surrounding Roseburg. The crater is located just off the left of this picture.

Chief Starmer's Post-Mortem Report to NFPA

"It is recognized by fire fighting services that a post-mortem on a fire, large or small, offers invaluable information in determining the operational strengths and weaknesses within the department. In like manner, a disaster and conflagration of the proportion suffered here in Roseburg becomes of vital interest to the public safety forces of the state and to the nation as a whole. Not to make the most critical analysis possible of the situation, not to disseminate all information in hopes of preventing a similar occurrence here or elsewhere would be nothing less than a desecration to those whose lives the disaster claimed. With this thought in mind I will attempt to evaluate and criticize the actions of myself and the other firemen, citizens, departments, and organizations who participated in the Roseburg fire and explosion, August 7, 1959. It must be recognized that the comments and observations made by myself here are subject to those errors of evaluation in memory to which we are all vulnerable, aggravated by the fact that at the time I was working under tremendous pressure and nervous tension resulting from the combined elements of a conflagration expanding with kaleidoscopic speed and a realization of the loss of life of fellow fireman and citizens.

Mutual Aid Rendered

"It should be clearly understood that Roseburg's fire defenses, adequate for protection in a normal emergency, could not by themselves have contained the fire within the limits to which it was confined. The quick action of companies responding to the Mutual Aid call, their initiative and good judgment in establishing and holding fire lines, the response of firemen on the scene conditioned by previous training to act automatically in emergencies even though suffering shock from the blast, the quick action and cooperation of the Police Department, protective actions by individual citizens, all these factors and many others formed the pattern of superb cooperation that prevented untold additional loss. This cooperation established those fire lines that were held, making the total effort a success.

Command Lacking in Early Phase

"Analyzing my own actions, errors become obvious. Though of equal rank with other surviving officers I felt justified in assuming command at the fire because of seniority in rank and experience. Upon assuming command as ranking officer, it was my responsibility to direct the total operation at the fire scene. Instead, for some 15 or 20 minutes I tied myself to a single truck operation. During this interim responding companies had to use their own initiatives in choosing the attack points. The strategy of the locations so chosen is a credit to the officers in charge of the responding companies. Upon removing myself from the immediate situation and making a survey, I found that the fire lines to protect exposures had been adequately established on all fronts except the southern, a situation that was quickly remedied. During this same interim, organized search and rescue was not being directed. Thanks only to the independent actions of various firemen, police, and private citizens this was accomplished.

Maintaining Fire Front

"Referring back to the time at which I approached the fire scene, the blast had occurred perhaps a minute prior to my company's arrival. During the ensuing two or three minutes we laid 1,000 feet of hose, attaching 4 nozzles. During this time, due probably to the upsurging draft caused by the blast, the immediate area was relatively cool with little evidence of fire spread. Suddenly we were enveloped in a fire storm* from which we barely escaped with our men and apparatus. The hoses and nozzles had to be abandoned, clearly indicating here the need for the prompt and accurate size-up of the situation, the employing of equipment outside the fire limits and the making of those sacrifices necessary to establish fire lines that offer the best opportunity to make a stop. Within these boundaries, evacuation and rescue should be made with utmost dispatch. With the limited resources of the community, even including Mutual Aid, there is little possibility of establishing a second line of defense. Each retreat lengthens the fire front and compounds control difficulties. Once established, the fire lines usually commit the officer to a last ditch fight. Again, in retrospect, it seems to me that I should have utilized all of Roseburg's equipment on the immediate problem and relied upon incoming aid to check outlying spot fires instead of reserving, as I did, one truck for that purpose.

*For a description of a fire storm see Chapter 67 of the 11th Edition of the NFPA *Handbook for Fire Protection*.

"I have mentioned tactical and judgmental improvements that might have facilitated controls in this instance. Now, I wish to turn to those weaknesses and strengths in administrative policy, operational procedures, and equipment and housing that were brought to light in the recent catastrophe.

State Training Helped

"Under the able direction of the State Fire Marshal Office, a Mutual Aid Program has been in effective operation as of the first of the year (1959) in this county. During the formulative program, periodically over the last year, the Department of Vocational Education has conducted three area training sessions on the various aspects of fire control which involved most of the departments committed to Mutual Aid. This combined training not only improved the efficiency of the individual departments participating, but also provided an opportunity for their respective familiarization with other departments' equipment, and the basis for standardization of methods for attack. It is my opinion that this smoothly operating Mutual Aid Training proved of incalculable value to our community.

"A fire department to function efficiently must operate in time of emergency like well-oiled machinery. This type of operation can only be obtained by continuous drill or training. The value of such training has been substantiated in the attack on Garretsen's. A pre-Fire Plan directed the movements, not only in the initial response, but after the explosion in protecting Cal-Pacific's propane storage tanks. This latter attack was made by men shocked and injured by the explosion. It behooves any department to take advantage of all facilities for training, both locally and from outside sources.

Communications Difficulty

"In directing the incoming Mutual Aid equipment, a definite handicap resulted from having no common radio frequency. No truck-to-truck communication was possible among departments. A little cooperative planning can rectify this situation. Within the city's own communication system the power shut off approximately 30 minutes after the blast interrupted truck to headquarters contact for the duration of the fire, clearly indicating the need for an independent emergency generator. Consideration should be given to establishing a central communications system operated by full-time personnel not assigned to concurrent fire or police duties.

Public Support for Fire Defense

"It is understandable in view of rapidly expanding economy and constantly rising taxes, the hesitance of the taxpayer to assume an additional burden. Yet the city administration must be realistic in its actions and be willing to assume the responsibility of making it clear to all concerned that such curtailment is a calculative risk that affects the life and property of the city. The lines of free and honest communication must be kept open between administrators and departments as well as between the administrators and the public.

Decentralizing City Defenses

"The structural damage suffered by the city hall brings up another problem worth considering. That is the advisability of decentralizing the department. Had the structure collapsed, it would have caused an additional loss of equipment desperately needed at this time.

Need for Adequate Fire Codes

"In respect to a fire inspection program, fire prevention, and adequate fire ordinances, Roseburg has been sadly negligent. The cost of inertia in this direction can lead only to unnecessary destruction of life and property. The city is now adopting fire ordinances patterned after the model set forth by the National Fire Protection Association and modified to fit the local situation. This code should be subject to periodic revision to keep it current, and adequate measures should be taken to insure an inspection and enforcement program.

Protective Clothing Needs

"A medical examination of Wescott's burns indicated that they were primarily the result of radiated heat. He was protected by black turn-outs with built-in liner. It seems likely these injuries could have been prevented had he been wearing . . . some other style protective clothing with better reflection characteristics. Also indicated is a need to make provisions for all off-duty firemen responding directly to the fire to have their protective clothing available.

Conclusions

"In a brief résumé, the following conclusions might be tabulated:

1. Within the department, a definite chain of command should be established down to the last officer.

2. A well-organized training program should be maintained with money budgeted for cost of state-conducted training.

3. Radio communications both within the city and within the Mutual Aid organization should be revamped with an auxiliary power supply provided.

4. Standardization of drill evolutions and equipment within the Mutual Aid organizations should be encouraged.

5. All phases of the city's fire protection should be subjected to critical analysis with a view to improving same.

6. A definite fire code, fire prevention policy, and inspection program implemented.

7. Effective plans made and projected into the future to provide the financing necessary for maintaining effective fire protection.

8. Interbureau relations and public relations improved through better communications."

Conflagration at Vastervik, Sweden

The American Swedish News Exchange, Inc.

A fire that has been described as probably the largest within a Swedish city in modern times occurred at Vastervik on August 27, 1959. On the day of the outbreak winds of 30-45 mph were prevalent and for two months there had been an unusual dry period in the area.

The fire started at a town dump when a rubbish fire went out of control. As firemen struggled to subdue it, burning paper blew into an adjacent wooded area and ignited dried grass and bushes. Flames jumped to high spruce trees and spread rapidly.

Fire departments from 17 cities and towns worked to keep the fire from entering the built-up section of the city. They were severely handicapped by poor water supplies and nonstandard hose couplings, and it was probably because the wind blew the fire along one side of the built-up area rather than directly into it, that only 13 buildings were destroyed. Using water hauled to the fire in trucks and relayed from lakes and the harbor by pumpers, fire fighters (aided by military personnel, civil defense crews, and citizens) brought the fire under control on August 28. It was not until September 27 that all manpower could be released.

A Life Hazard . . .

Inadequate Vents on Flammable Liquid Tanks

By Miles E. Woodworth

NFPA Flammable Liquids Engineer

Member, Society of Fire Protection Engineers

Since 1954 forty-one firemen in the United States have lost their lives because of failure to provide adequately sized and designed emergency vents on aboveground flammable liquid storage tanks.

Fatal Fires

On October 28, 1954, in Philadelphia, Pa., ten firemen were killed when a pressure tank ruptured violently. A chemical reaction took place in the flammable liquid in the tank and because of a plugged, inadequate one-inch vent, the build-up of pressure from the reaction caused the tank to fail. (See NFPA *Fire News*, December 1954.)

Philadelphia Fire Department

A plugged inadequate one-inch vent caused failure of a tank in this Philadelphia industrial plant, and ten firemen lost their lives.

On May 18, 1956, two firemen were killed in Galena, Md., when a horizontal tank skyrocketed during a fire when one end of the tank failed. This failure was caused by flame impinging on the tank shell from burning vapors from the two-inch vent causing the metal to soften. (See NFPA *Flammable Liquid Fire Loss Bulletin*, Series 1956–1.)

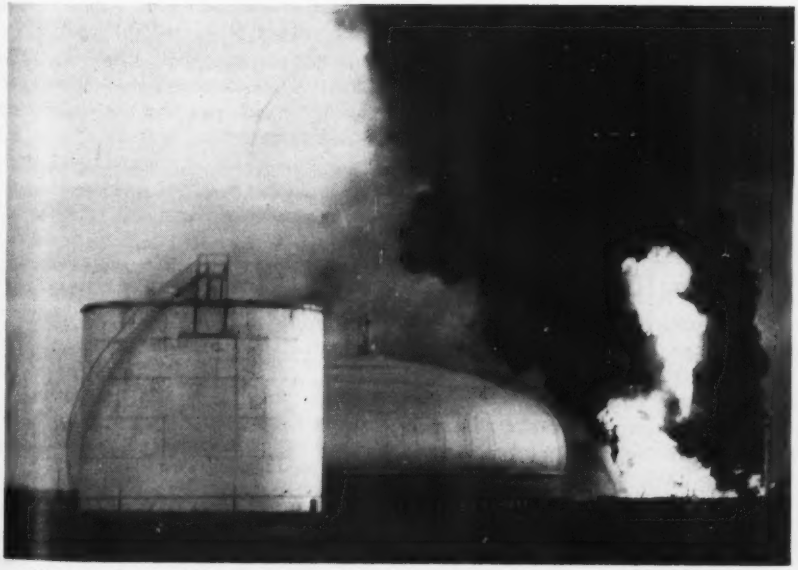
On July 19, 1956, nineteen firemen were killed near Dumas, Texas, fighting a fire involving a spheroid type tank when it suddenly ruptured releasing a huge ball of burning liquid. This failure was caused when burning vapors from the tank vent impinged on the tank shell causing the metal to soften and the sudden rupture of the tank. (See NFPA Quarterly, October 1956, Vol. 50, No. 2, and Reprint Q50–3.)

On August 22, 1957, four firemen were killed in Highmore, South Dakota, when a 375-gallon diesel oil tank ruptured or exploded during a fire which destroyed a farm-equipment building. The tank was located adjacent to the building and one reputable source reported that the tank was equipped with only a ¾-inch vent. Burning diesel oil was sprayed over the firemen when the tank failed. (See NFPA *Fire News*, October 1957.)

On August 18, 1959, six firemen were killed in Kansas City, Kansas, when a 21,000-gallon horizontal tank exposed

Associated Press

A state policeman clicked this photo as a horizontal tank ruptured in Galena, Maryland, after flame impingement on the tank from a two-inch vent caused tank failure. Two firemen died.



Nineteen firemen died fighting this fire in a refinery near Dumas, Texas, when a spheroid tank ruptured. Again, flame impingement on the tank from the vent was responsible for the tank failure.

to fire skyrocketed 94 feet into the street. This tank was equipped with only a two-inch combination flame arrester-vent valve which provided less than five per cent of the emergency venting recommended in the Flammable Liquids Code, and, as a result, the tank failed from overpressure. (See NFPA QUARTERLY, October 1959, Frontispiece, and NFPA *Firemen* Magazine, November 1959.)

Function of Emergency Vents

Emergency relief means are necessary on all aboveground flammable liquid tanks in order to prevent overpressuring the tank when it is exposed to fire as well as to handle the increased pressure caused by some types of uncontrolled chemical reactions.

The violent overpressure failure of these tanks has sometimes been compared to the more familiar dry boiler "explosion." Build-up of pressure within a tank should be distinguished from an internal explosion of a flammable vapor-air mixture, although the overpressure failure of a tank may be equally or even more violent than an internal explosion. For this reason, the Flammable Liquids Code, NFPA No. 30, is very specific and detailed on not only the size but also the design of emergency vents and other means of securing emergency pressure relief.

Function of Normal Breather Vents

Unfortunately, many flammable liquid storage tanks in use are not equipped with adequate emergency relief means. The only vents provided for many low pressure tanks and pressure vessels are those for normal breathing.

Normal breather vents are installed on all tanks to prevent damage to the tank during maximum filling or emptying operations. A breather vent is also necessary to equalize pressures when a tank is cooled during a sudden rainstorm on a hot day.

Because of the failure to install adequate normal breather vents, many tanks have been collapsed or bulged. Adequate normal breather vents are thus needed for the protection of tanks, but adequate emergency vents or relief means are important for the protection of not only property, but, more important, the protection of lives.

The Flammable Liquids Code, NFPA No. 30, covers the subject of normal breathing as follows:

2131. NORMAL BREATHING:

(a) Tanks shall have normal venting capacity sufficient to permit the filling and emptying of such tanks, plus their breathing due to temperature changes, without distortion of tank shell or roof.

(b) Tanks storing Class I and Class II flammable liquids shall be equipped where practical with either venting devices which shall be normally closed when not under pressure or vacuum, or with approved flame arresters, except as provided in subparagraph (c) below.

(c) Tanks under 2,500 gallons capacity for Class I liquids and tanks under 3,000 barrels capacity for crude petroleum in producing areas may have open vents.

NOTES: See American Petroleum Institute Guide for Tank Venting — R.P. 2000, October 1952, for additional venting information.

Condensation, corrosiveness, and crystallization of certain products and freezing in winter may make conservation vents and particularly flame arresters impractical for those products and for use in very cold weather.

Where the liquids stored have flash points in the range of normal summer temperatures, the vapor space above the liquid in the tank will normally contain vapors in the explosive range. On such tanks flame arresters have their most important application.

Influence of Tank Design on Vents

In discussing emergency venting and relief methods, it is first necessary to consider some of the different types of storage tanks. There are many differ-

ent types of storage tanks for flammable liquids which have been developed for special purposes. However, in the consideration of emergency venting and relief, this discussion will be limited to the important feature which is pressure.

Atmospheric Tanks

If a tank is designed to fail at less than 0.5 pounds per square inch (psi), there is no need for emergency vents as it is unlikely that pressures will build up to dangerous proportions in such tanks. The most common of the atmospheric tanks is the cone-roofed tank (Figure 1).

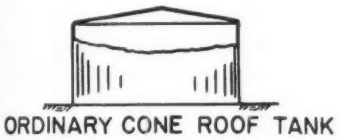


Figure 1.

These tanks are built to withstand not more than 0.5 psi and secure their emergency relief means by a roof-to-shell seam or joint of weak construction. Shop-built vertical tanks, labeled by Underwriters' Laboratories, Inc., and field-erected tanks, built in accordance with the American Petroleum Institute's Specification for Welded Storage Tanks (No. 12C), have this same weak roof-to-shell seam (see Figure 2). Atmospheric tanks over 36 feet in diameter built in accordance with the API Specifications also are considered to have an inherently weak roof-to-shell seam. Atmospheric tanks with weak roof-to-shell seams thus require normal breather vents but do not require emergency vents.

The result of designing a weak roof-to-shell joint, having less strength than the bottom-to-shell seam, is that the roof tears loose first under pressure or an internal explosion. For this reason the entire roof serves as an emergency

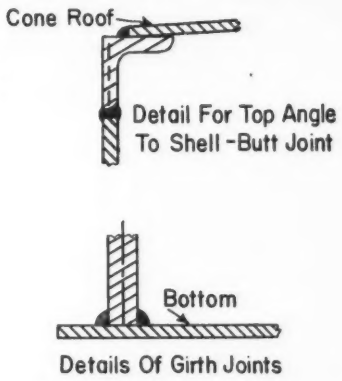
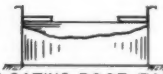


Figure 2. Typical tank construction to provide a weak roof-to-shell seam or joint. The weld at the bottom-to-shell tank is on both sides of the shell and is thicker than permitted for the one weld at the roof-to-shell seam. In addition, the roof is not welded directly to the shell but to an angle iron attached to the shell. This construction assures the separation of the roof-to-shell seam at a pressure of approximately three inches of water.

vent and the liquid remains in the tank. The many instances where such tanks have been subjected to exposure fire or internal explosions substantiate the effectiveness of this design as a pressure relief means. In a few cases where vertical tanks have not been equipped with weakened roof-to-shell seams nor with adequate emergency vents, the tanks have "skyrocketed" and resulted in releasing the entire contents of the tank. One such fire in 1949 in Perth Amboy, New Jersey, killed four firemen who were caught in the wave of suddenly released burning asphalt when the bottom-to-shell seam failed first causing the tank to skyrocket (see photo next page).

One other popular atmospheric type tank is the floating roof type (see Figure 3) which has no vapor space and consequently has no venting problem. Still another is the lifter roof tank (see Fig-



FLOATING ROOF TANK
Roof deck rests upon liquid and moves upward and downward with level changes

Figure 3.

LIFTER ROOF TANK
Liquid-sealed roof moves upward and downward with vapor volume changes

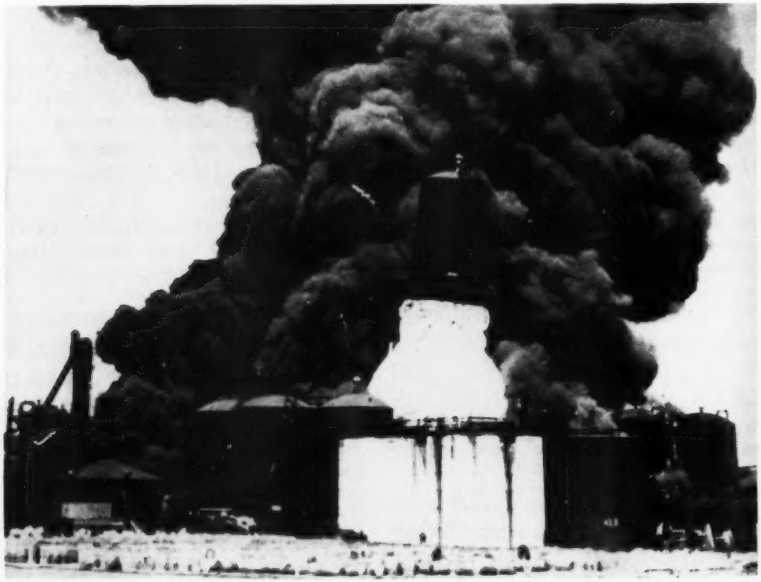
Figure 4.

ure 4) which has a liquid-sealed roof which moves upward and downward with vapor volume changes. Excess pressure is vented through the liquid seal.

Pressure Tanks and Vessels

Low pressure tanks are those designed to withstand pressures greater than 0.5 psi but not more than 15 psi. The most common of this category are the conventional horizontal tanks. However, also included in this group are vertical tanks not equipped with a weak roof-to-shell seam, certain spheroid tanks and others that do not class as pressure vessels.

Pressure vessels are those designed to withstand pressures of over 15 psi. The most common of the pressure vessels for the storage of flammable liquids are spheres and certain spheroids. A pressure tank or vessel may be classed as an atmospheric tank if it is equipped with a vent that would prevent pressure from exceeding 0.5 psi, even under the most severe exposure fire since the possibility of the tank rupturing violently from over-pressure is greatly lessened.



Wide World

Where tanks are not equipped with emergency relief means, they can constitute a serious fire-fighting problem under fire conditions. See previous page for remarks on this fire at Perth Amboy, N. J.

Such venting capacity may be accomplished by: (1) the use of large or multiple open vents, (2) the use of large or multiple vents equipped with flame arresters or pressure-vacuum vent, (3) a gage hatch so designed to permit the cover to lift under the range of abnormal internal pressures which might develop, or (4) a manhole cover arranged to operate in a similar way to the gage hatch.

Size of Emergency Vents

As previously explained, atmospheric tanks such as cone-roofed tanks with a weak roof-to-shell seam and lifter roof tanks are not required to have emergency vents in view of the built-in emergency relief provided for by the design of these types. Floating roof tanks are similarly not a problem. However, all other tanks must be equipped with emergency vents if the lives of firemen and others are to be saved under fire exposure conditions. These vents should be at least as large as those required in the table printed on this page. For a tank operating at pressures greater than those given in this table, emergency relief valves shall have at least the same relief capacity in cubic feet of "free" air per hour, based on the size of the tank as given in the table.

The requirements for the emergency venting of flammable liquid tanks in NFPA No. 30 are as follows:

2132. EMERGENCY RELIEF:

(a) Every aboveground storage tank shall have some form of construction or device that will relieve excessive internal pressure, caused by exposure fires, that might cause the rupture of the tank shell or bottom.

(b) In a vertical tank, this construction may take the form of a weakened seam in the roof. The joint between the roof and the shell of a tank 36 feet or more in diameter, if designed and built as an atmospheric storage tank in accordance with Paragraph 2021 (of NFPA No. 30), shall be deemed to be a weakened seam for this purpose.

Required Total Pressure Relief Capacity of Vents*

Capacity of Tank Gallons	Capacity of Tank 42-Gallon Barrels	Minimum Total Pressure Relief Capacity (Cu. Ft. of Free Air Per Hour)	Approximate Diameter in Inches of Free Circular Opening for Various Pressures 3 In. of Water	1 PSI	2½ PSI	5 PSI
1,000 or less	23.8	25,300	4	2½	2	1½
4,000	95.2	69,500	6¾	3¾	3	2½
18,000	428	139,000	9½	5½	4¼	3¾
25,000	595	166,000	10¼	6	4¾	4
56,000	1,330	253,000	12¾	7¼	5¾	5
100,000	2,380	363,000	15¼	8¾	7	6
155,000	3,690	458,000	17¼	9¾	7¾	6½
222,000	5,290	522,000	18¼	10½	8¼	7
475,000	11,300	624,000	20	11¼	9	7¾
735,000	17,500	648,000	20	11½	9¼	7¾
Unlimited		648,000	20	11½	9¼	7¾

NOTE: Venting equipment installed for normal operation may serve as emergency relief, provided that it has the requisite capacity under the pressure limitation fixed by this table. Responsibility for selecting the limiting pressure is placed on the owner or operator.

*This table is identical with Table 3 of NFPA No. 30. The NFPA Committee on Flammable Liquids currently has a subcommittee studying the adequacy of this emergency venting table. Although there are no substantiated fire experiences to show that tanks equipped with emergency vents as required in NFPA No. 30 have failed from overpressure, there have been tests which would indicate that the smaller sized tanks should have the emergency vent sizes increased. It is hoped that in due course a recommendation can be made to an NFPA Annual Meeting which will resolve the many differences of opinion currently existing on emergency vent sizes.

(c) Where entire dependence for such additional relief is placed upon some device other than a weak roof seam or joint, the total venting capacity of both normal and emergency vents shall be enough to prevent rupture of the shell or bottom of the tank if vertical, or of the shell or heads if horizontal. Such device may be a self-closing manhole cover, or one using long bolts that permits the cover to lift under internal pressure, or an additional or larger relief valve or valves. For the purpose of computing the number and area of such vents and emergency relief devices, reference may be made to the following Table.

The table indicates that there are two major factors to be considered in selecting emergency venting. The first is to select the limiting pressure at which the tank is to be operated taking into consideration the design strength of the tank. The second is to secure an emergency vent which has a relief capacity in cubic feet of "free" air per hour as required for the size of the tank and the pressure at which it is to be operated.

It should be pointed out that the size of vents refers to the approximate diameter in inches of an unobstructed circular opening. The only time such an unobstructed circular opening could be used is where a 12-inch or shorter straight open pipe is employed with no venting device on the end of the pipe. This type pipe can be used on tanks containing a Class III flammable liquid. Obviously the addition of any device (such as a relief valve, pressure-vacuum vent, or flame arrester) on the end of a vent pipe will restrict the flow of vapor and, therefore, a larger pipe size would be needed than if the pipe were unobstructed. Therefore, the company which manufactures the venting device must specify the capacity of its vent at the pressure indicated. This capacity must comply with the requirements of the table for the pressure design of the tank.

In effect, then, the size of the vent pipe would of necessity have to be increased over the size mentioned in the table depending on the restrictions in the individual venting device. This restriction might very well mean a considerable increase in the size of the vent pipe mentioned in the table. For example, a 4,000-gallon tank would be required to have an emergency venting capacity of 69,500 cubic feet of "free" air per hour. This could be accomplished by providing a 6¾-inch unobstructed vent if three inches of water were the desired pressure. According to Underwriters' Laboratories, Inc., an 8-inch vent would be required to maintain this same capacity when equipped with a flame arrester.

Design of Vent Outlets

Equally important with the size of the emergency vents is their design for any low pressure storage tank or pressure vessel. This important design feature is covered in NFPA No. 30 as follows:

2133. The outlet of all vents and vent drains on tanks designed for 0.5 pounds per square inch or greater pressure shall be arranged to discharge in such a way as to prevent localized overheating of any part of the tank, in the event vapors from such vents are ignited.

The two fires occurring in 1956 which killed a total of 21 firemen (see page 209) were without doubt caused by localized overheating of the tank shell. In fact, in both of these cases there was direct flame impingement on the tank from the burning vapors emerging from the downward pointing emergency vents. (See Figure 5 for schematic diagram.) Investigations of these two tanks disclosed thinning-out to razor sharpness of the steel at the point where the tank failed. With steels of the types used for flammable liquid tanks, a straight overpressure failure would have resulted in a brittle fracture instead of stretching of the overheated steel.

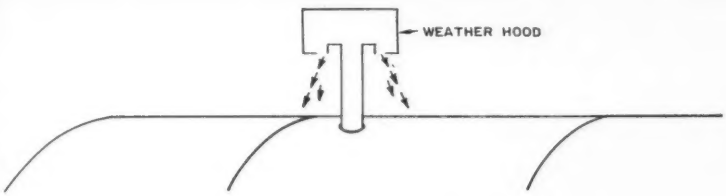


Figure 5. Localized overheating of the tank shell can occur from flame impingement on the shell from improperly designed vents as illustrated in the schematic diagram.

As a result of these two fires the Flammable Liquids Code was changed in 1957, as indicated in the previously cited Paragraph 2133, to eliminate this hazard.

It is interesting to note that a similar problem had been forcefully drawn to the attention of the NFPA Committee on Gases a number of years ago when discharge from drains at the base of safety relief valve vent lines became ignited during a serious fire and impinged on the shell of the container causing failure. Following this fire appropriate wording was incorporated in the Standard for the Storage and Handling of Liquefied Petroleum Gases, NFPA No. 58, under Paragraph 2.3(b)5, to guard against "impingement of flame resulting from ignition of product escaping from the drain."

Action Needed Now

Fortunately, the frequency of fires involving and exposing aboveground flammable liquid tanks is low; however, the severity is high and the Flammable Liquids Code states that where there is a proven, distinct hazard to life and property, the provisions of this Code can be made retroactive.

Since 1954 there have been 41 fire fighters killed because of improper or inadequate venting or emergency relief means during fires involving flammable liquid tanks. These added to those who have died before* make it imperative that corrective steps be taken *now*.

Any regulatory official under his broad police powers can and should require that all existing aboveground flammable liquid tanks not inherently provided with emergency relief means by their design be provided with emergency vents of at least the capacity and design required in the Flammable Liquids Code.

Every owner of such an aboveground flammable liquid tank should immediately and voluntarily take action to provide adequate and properly designed emergency vents.

The manufacturers of emergency vents and safety relief devices should design these devices to prevent localized overheating of the tank shell caused by burning vapors from the vent. The flow capacity of all such emergency vents and relief devices should be provided.

Other Considerations

There are other factors which need to be considered when emergency vents are to be installed on existing tanks. These factors are: (1) the unprotected steel

*For example: On June 18, 1934, in Jamestown, New York, four firemen and three spectators were killed when two tanks (10,000 gallons and 20,000 gallons capacity) ruptured suddenly from internal pressure. These tanks were equipped with 2¼-inch vents. (See NFPA QUARTERLY, July 1934, pages 52–60.)

supports commonly used to support horizontal tanks, and (2) the explosion hazard that may be created by cutting a vent hole in a tank containing a flammable liquid.

Unprotected Steel Supports for Tanks

Steel supports for aboveground flammable liquid tanks are required by NFPA No. 30 to be protected by materials providing at least two hours fire resistance. The numerous fires involving such unprotected steel supports clearly indicate the distinct hazard of such installations. The unprotected steel supports often fail under exposure fire conditions, permitting the tank to drop to the ground before sufficient pressure is built up to overpressure the tank. In some cases the tank has been broken open by this sudden collapse and in other cases only the piping has been broken off. Regardless, the tank contents are then added to the fire and the magnitude of the fire may be suddenly increased with possible hazard to life and beyond the capabilities of the firemen to protect exposed property.

Therefore, in existing installations, emergency vents or relief means may not be all that is required. Where tanks are supported by unprotected steel supports and could create a hazard to the public or to the fire service, the supports should be protected as recommended by NFPA No. 30. Each installation does have to be evaluated separately before going to the expense of correcting existing installations. Still other considerations would be such factors as the provision of thermal heat-actuated valves at tank outlets, the slope of the ground, the distance separation of loading racks from aboveground tankage, the use and arrangement of dikes, and the installation of spring-operated loading valves on transfer equipment. There is no question, however, that all new tank installations using steel supports should be required to have the steel protected.

Hazards of Installation of Larger Vents

Another important factor is the explosion hazard that may be created by the cutting of a larger hole in a tank to install an emergency vent. If a cutting torch is used to make this opening, the tank atmosphere must be gas free or inerted regardless of the flash point of the liquid in the tank. On the other hand, it is possible to cut such an opening by the use of a "cold-cutting" piece of equipment which operates on much the same principle as a pipe-cutter. Before a cutting torch is used, reference should be made to "Cleaning and Safeguarding Small Tanks and Containers," NFPA No. 327* or to "Accident Prevention Manual No. 1, Cleaning Petroleum Storage Tanks, Section B: Gasoline."†

Summary

Forty-one fire fighters have lost their lives since 1954 because of the failure to provide emergency vents or relief means of the capacity and design recommended by the Flammable Liquids Code, NFPA No. 30. The lessons are clear cut and the fire record proves the hazard to fire fighters. Unless more fire fighters are to be needlessly killed, regulatory officials and the owners of flammable liquid storage tanks must take action now. Emergency vents of at least the capacity and design called for in NFPA No. 30 should be installed on all existing as well as new tank installations! The allied problem presented by unprotected steel supports also demands evaluation in each installation. Proper procedures must be followed to gas-free any tank on which "hot" work is to be performed.

*Available from the National Fire Protection Assn. Price 40 cents.

†Available from the American Petroleum Institute, 1271 Avenue of the Americas, New York 20, N. Y. Price $1.00.

Ammonium Nitrate — Behavior in Fires

By Chester I. Babcock

Manager, NFPA Fire Record Department
Member, Society of Fire Protection Engineers

From inquiries received continually by the NFPA, it is apparent that there are many questions in the minds of fire protection people pertaining to the behavior of ammonium nitrate under fire conditions.

At Texas City, Texas, on April 16, 1947, two ammonium nitrate explosions killed at least 468 persons and caused an estimated $67,000,000 property damage. These explosions occurred during fires in ships' holds containing this material. Despite the fact that there has never been a reported explosion of ammonium nitrate under fire exposure while in storage in a building, or while in a truck or freight car, it was vital to establish whether such an explosion was possible, with increasingly large tonnages of ammonium nitrate being shipped and stored.

An explosion that occurred at Roseburg, Oregon, on August 7, 1959, was erroneously reported in some early accounts as having involved a truckload of ammonium nitrate. The truck actually contained 4000 pounds of dynamite and 9000 pounds of a blasting agent. The blasting agent consisted of a mixture of ammonium nitrate, ground walnut shells and diesel oil. Blasting agents should not be confused with ammonium nitrate. They are much more sensitive to detonation initiated by an explosive than are pure or fertilizer grades of ammonium nitrate. For a report of the Roseburg explosion see page 195 of this issue of the QUARTERLY.

Intensive studies were therefore undertaken to determine what conditions were necessary for an explosion to occur during a fire involving ammonium nitrate. As a result of these studies information has been developed that permits a precise characterization of ammonium nitrate and its fire hazard properties. Procedures for storing and for fighting fires involving ammonium nitrate have also been evolved.

The NFPA acknowledges assistance given in the preparation of this report by Ralph Miller and Sam Porter of the Spencer Chemical Co. and William Doyle of the Factory Insurance Association.

Conditions Necessary for Explosion

From a study of the properties of ammonium nitrate and from tests, it has been concluded that *both* high pressures and high temperatures are required before ammonium nitrate will explode under fire conditions. It has also become evident that some contaminants increase the sensitivity of ammonium nitrate and that others decrease it.

Temperature

When ammonium nitrate is heated to about 210°C (410°F) it starts to decompose into nitrous oxide and water vapor. The speed of the decomposition reaction increases as the temperature of the ammonium nitrate increases and when this approaches 450°C (842°F) it is in the range where detonation can occur.

Since heat is released by the decomposition of ammonium nitrate into nitrous oxide and water vapor, does it therefore follow that, once decomposition starts, the decomposing ammonium nitrate will become progressively hotter until temperatures necessary for explosive decomposition are reached? Fortunately, this is not the case under normal conditions since another process also takes place when ammonium nitrate is heated — the vaporization and dissociation of ammonium nitrate into ammonia and nitric acid. This latter process *absorbs* heat.

Pressure

The key to whether temperatures high enough to cause explosive decomposition are reached is the amount of pressure to which the decomposing ammonium nitrate is subjected. The effect of pressure on temperature is discussed in "Ammonium Nitrate and High-Percentage Ammonium Nitrate."* From data in this paper it can be concluded that a pressure of about 80 atmospheres (1176 psi) will stop the heat absorbing (endothermic) reaction in the case of chemically pure ammonium nitrate, and about 20 atmospheres (294 psi) will stop the endothermic reaction in the case of wax-coated ammonium nitrate. Once the endothermic reaction stops, the ammonium nitrate will heat rapidly to its detonation temperature.

Under ideal conditions pressures of the magnitude of 20 atmospheres are possible in a fire involving a large, closely packed pile of bagged wax-coated ammonium nitrate such as could be found in a ship's hold. In a warehouse, truck, or freight car, however, attainment of such pressures does not appear to be probable. Practical limitations in the size of storage piles in buildings, trucks, and freight cars minimize the possibility that the pile itself, because of its size, could retain dangerous pressures. Recommended procedures for storage of bagged ammonium nitrate in buildings (see page 219) provide means for escape of heat and gases from the storage. Natural ventilation through walls, doors, etc., and ventilation due to fire conditions (skylight and window breakage, roof, and wall burn-through, etc.) also facilitate escape of heat and the gaseous products of combustion.

The report by the Interagency Committee on the Hazards in Transportation of Ammonium Nitrate (Part III),† contains the following conclusion: "No runaway temperature and pressure rise will occur, so long as the water, ammonia, nitric acid, and nitrous oxide can escape freely, or in other words, so long as the pressure above the decomposing ammonium nitrate is not too high. If the system is contained or confined, then the pressure and temperature will rise, and explosive decomposition will occur unless all of the ammonium nitrate decomposes before the very high pressure necessary for explosion is reached."

Tests conducted by the Bureau of Mines‡ also point to the conclusion that high temperatures and high pressures are both prerequisites for an explosion, and indicate that the presence of foreign organic material can significantly reduce the temperatures and pressures necessary for an explosion.

Effects of Contaminants

The ammonium nitrate that exploded at Texas City had a wax coating on individual granules. It is now generally agreed that this wax coating increased the sensitivity of the ammonium nitrate. This was due in part to the combustion of the wax which released heat to the mass of the ammonium nitrate. Burning of paper bags and wooden dunnage also provided heat to raise the temperature of the nitrate.

When general agreement was reached that combustion of the wax coating on granules was an important factor in the development of dangerously high temperatures at Texas City, the use of wax or other combustible coatings was discontinued on fertilizer-grade ammonium

*By R. M. Hainer and Warren C. Lothrop, Arthur D. Little, Inc.

†Published by the Treasury Department, U. S. Coast Guard, Washington, D. C.

‡Report of Investigations 4994. Single copies available only from The Publications Distribution Section, Bureau of Mines, 4800 Forbes St., Pittsburgh 13, Pa.

nitrate. Where a coating is required to prevent caking, a noncombustible material is now used. Wax-coated ammonium nitrate is still used in the manufacture of commercial explosives.

Research has also indicated that contamination by other organic materials as well as by certain inorganic materials will have a similar effect. On the other hand, certain inert materials will reduce the sensitivity of ammonium nitrate. However, the contamination problem has not as yet been thoroughly investigated, and until more is known about materials that should be classified as dangerous contaminants, it is good practice to segregate stored ammonium nitrate so that mixing with other materials will not be possible.

Ammonium Nitrate an Oxidizing Agent

Ammonium nitrate is an oxidizing agent, and like sodium nitrate and other inorganic nitrates, will increase the intensity of burning of a fire. Evidence of this property will be found among the fire reports summarized elsewhere in this article. Because of this property it is desirable to segregate ammonium nitrate from combustible storage and to take care to prevent the accumulation of ammonium nitrate dust on structural members.

Recommended Storage in Buildings

Manual A–10, issued by the Manufacturing Chemists' Association, Inc.,* contains the following recommendations for the storage of fertilizer-grade ammonium nitrate in buildings. They were adapted from the proceedings of the Conference on Ammonium Nitrate Fertilizer of the National Research Council of Canada.

*Available from the Manufacturing Chemists' Association, Inc., 1825 Connecticut Ave., N. W., Washington 9, D. C. Price 50 cents.

These recommendations have not been reviewed by the NFPA Committee on Chemicals and Explosives and have no official NFPA status. They are reprinted here as being what is generally considered to be the best information on the subject currently in print.

The NFPA Committee on Chemicals and Explosives has recently undertaken to develop recommendations for the storage of ammonium nitrate. The Committee may agree with some of the items below, differ with others and may feel that certain additional recommendations are needed. It is to be expected, for example, that among the subjects to be given careful consideration will be a recommendation for automatic sprinkler protection, the question of what aisle widths should be recommended, and the extent to which certain combustible materials should be segregated from ammonium nitrate to prevent possible contamination.

MCA Storage Recommendations

1. Bags of ammonium nitrate fertilizer should be stored not less than thirty inches from the storage building walls in piles not more than twelve feet in width, with thirty-inch aisleways between piles. Bags should not be stored closer than thirty-six inches from the eaves of the roof or supporting and spreader beams overhead.

2. Roofs and floors above masonry or concrete walls should be of lightweight construction and should not be of concrete or masonry. Wooden structures are authorized.

3. Ammonium nitrate fertilizer should not be stored in any structure in which any explosives are kept.

4. Warehouses or structures used for storage purposes should be clean and be maintained in good housekeeping order.

5. Ammonium nitrate fertilizer should not be stored over or under any organic chemicals, flammable liquids, corrosive acids, chlorates, permanganates and the like, finely divided metals, sulfur, or combustible material other than dunnage. Storage piles should be at least thirty feet away from these materials.

6. The material should not be stored closer than three feet from steam or hot water pipes, radiators, heating devices, or electric wiring, fittings or switches.

7. Ammonium nitrate fertilizer may be stored on clean concrete floors or wooden pallets or dunnage on any type of clean floor. Floor drains into which molten nitrate can run during a fire should be eliminated or plugged.

8. Spilled material should be cleaned up promptly and disposed of. A broken or cracked bag containing uncontaminated fertilizer may be salvaged by placing it inside a clean new over-slip bag and closing securely.

9. Except at fertilizer manufacturing plants, ammonium nitrate fertilizer should be stored only in containers.

10. Smoking should not be permitted in or near storage spaces.

11. Open lights or flames should be prohibited in or near storage spaces.

12. Fire hydrants, exterior of the storage spaces and conveniently placed, with adequate hose available and capable of extension to all parts of the storage, should be provided.

Records of Fires and Explosions

From the discussion of the conditions believed necessary for explosive decomposition of ammonium nitrate, it can be understood why there has never been a substantiated report of an ammonium nitrate explosion during a fire in a building, truck, or railroad boxcar. This is further substantiated by the record of typical ammonium nitrate fires found on pages 222 to 230. The only explosions that have been reported have occurred: (1) under fire exposure in ships' holds where a large compact mass (28,000 100-pound bags in one hold of the *Grandcamp*) made a high degree of confinement possible; (2) where the explosions were initiated by the use of a high explosive to break up solidified masses of the material; or (3) during the manufacture of ammonium nitrate.*

Due to the necessarily limited sizes of piles in buildings, trucks, and freight cars, piling methods are such that build-up of temperatures and pressures within the pile do not develop to the place where an ammonium nitrate explosion will occur. Another factor helping to prevent the development of dangerous temperatures and pressures is the natural ventilation that can be expected in truck bodies, in boxcars, or in buildings of other than windowless, fire-resistive construction, plus the additional ventilation that is provided by the fire itself (failure of walls, roofs, windows, etc.). Add to the limitation of pile sizes and the existence of ventilation the fact that the composition of commercial ammonium nitrate has been changed to eliminate the combustible coating formerly on the granules, and it will be seen that fire fighters using recommended procedures can fight a fire in a building, truck, or boxcar containing ammonium nitrate without fear of an explosion.

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*The explosions at Texas City (July 1947 QUARTERLY), The Brest explosion (October 1947 QUARTERLY), and the *Tirrenia* explosion (July-August, 1953 *Fire News*), occurred during a fire in a ship's hold. The ammonium nitrate in each case was wax-coated. The Oppau, Germany, and Tessenderloo, Belgium, ammonium nitrate explosions are the most notable instances where initiation was by an explosive. A list of major fires and explosions involving ammonium nitrate is included in the NFPA report of the Texas City disaster.

Fighting Ammonium Nitrate Fires

The following recommendations for manual fire fighting have been adapted in part from the section on fire fighting in Manual Sheet A–10, "Fertilizer-Grade Ammonium Nitrate," published by the Manufacturing Chemists' Association, Inc. Like the storage recommendations they are not official NFPA standards, but are presented here as the best information currently available.

1. Apply water immediately and in as much volume as possible. Two-and-one-half-inch hose with a minimum 1⅛-inch tip capable of producing a 250 GPM stream with adequate pressure to supply a good range is recommended. The superior cooling effects of water spray, preferable for most fires, are not desired here, as fires in ammonium nitrate should be flooded. Bring as many hose streams of major size to bear on the fire as the capacity and pressure of the water supply permits.

2. Do not hesitate to apply water directly to the containers of the ammonium nitrate, inasmuch as instantaneous cooling is the desired objective.

3. Irrespective of the normal reaction of ventilation increasing the severity of a fire, it is recommended that barriers such as doors and windows of storage spaces be opened to provide as much ventilation as possible. Dissipation of gases of decomposition will reduce the possibility of pressure being built up and enhance the effectiveness of fire-fighting operations. It should be remembered that high temperature and pressure are factors to be avoided.

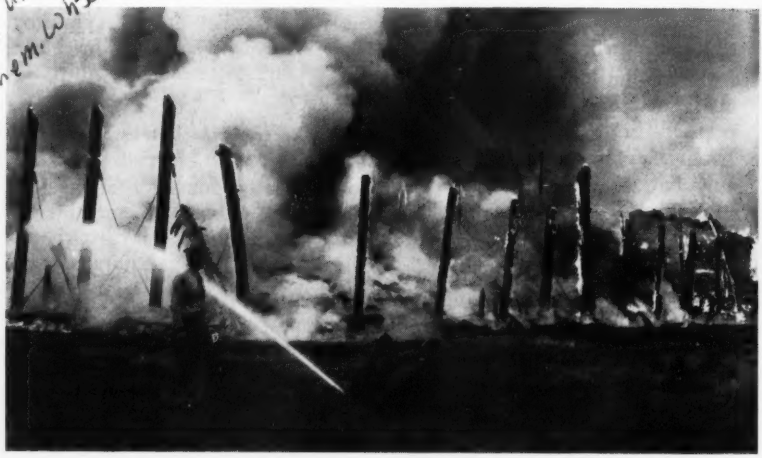
4. Care should be taken to prevent molten ammonium nitrate from entering floor drains and sewers. It is conceivable that such piping could provide the confinement necessary for build-up of pressure necessary to initiate an explosion.

5. *Vapors from burning ammonium nitrate are extremely toxic.* In this respect, the decomposition products of fertilizer-grade ammonium nitrate, do not differ from those of other nitrates. Self-contained respiratory protective equipment should be used in locating a fire or ventilating a building charged with these toxic gases. Oxides of nitrogen and carbon monoxide are the most dangerous of the gases likely to be encountered in such a fire.

6. If sufficient heat is present, it may happen that during the application of water, formation of steam in pockets in the piles of nitrate may cause eruptions with force comparable to minor explosions. For this reason it is judicious not to approach too close to the fire and not to become too alarmed at such steam eruptions. The fire fighter should protect himself by guiding the water from behind the shelter of the wall of the warehouse, at the corner of doorways, immediately below the sash of the windows or from behind any substantial barrier. The foregoing is not to be interpreted as superseding "on the spot" judgment. The quicker the temperature is lowered, the less likelihood there will be of steam eruptions and the generation of oxides of nitrogen. Rapid reduction of temperature is the essence of the entire control operation.

Typical Ammonium Nitrate Fires

Filed under Chem. Whse.



This warehouse at Independence, Kansas, contained 1,383.4 tons of bagged fertilizer-grade ammonium nitrate. The wooden building and most of its contents were destroyed by fire on Oct. 19, 1949.

Ammonium Nitrate Whse., Independence, Kans., Oct. 19, 1949, $325,000

Lightning was the probable cause of fire that broke out in a 175 ft. by 210 ft. 1-story wooden building in which 2,240 tons of alfalfa meal in 100-pound burlap bags was stored. Because of the method of storage (bags piled to the roof in some places and from wall to wall throughout) firemen were unable to control the fire with hose streams, and in fact the heat was so intense that they were forced to abandon a hydrant 40 ft. from the fire.

Forty feet from the alfalfa warehouse there was another 1-story wooden warehouse 140 ft. wide and 159 ft. long containing 1,383.4 tons of fertilizer-grade ammonium nitrate (similar to the material which exploded at Texas City). The ammonium nitrate was in 100-pound paper bags stacked in double rows, 15 ft. high, with 2½-ft. aisles between stacks and from walls. Fire fighters tried to prevent ignition of the ammonium nitrate warehouse but when the exposing wall on the alfalfa warehouse collapsed about 20 minutes after the fire was discovered, the roof and walls of the ammonium nitrate warehouse burst into flame. The stacks of bagged ammonium nitrate also ignited and the ammonium nitrate started to decompose giving a brown color to the smoke coming from the building. Since there was a breeze, fire fighters, by attacking the fire with hose streams from the windward side, were not endangered by the toxic gases. During the height of the fire, water supplies were adequate and after the ammonium nitrate fire was wet down for about 30 minutes, it was brought under control. At no time during the fire was there any evidence of an explosion.

The building was completely destroyed and all but between 100 and 150 tons of the 1,383.4 tons of fertilizer-grade ammonium decomposed. Most of the undecomposed ammonium nitrate was in a wet mushy state, intermingled with charred wood and charred paper.

Farm Bureau Warehouse, Veedersburg, Ind., April 11, 1950, $32,000

At 6:30 A.M. the waitress in a nearby cafe noticed fire in the second story of the unsprinklered 2-story brick, wood-joisted building. By then the fire had made considerable headway in the second story and could not be controlled with several hose streams directed on the fire by four volunteer

Fire in this Veedersburg, Indiana, warehouse was beyond control of volunteer fire departments when it reached 15 tons of ammonium nitrate stored in the first story. On learning that ammonium nitrate was involved, the Veedersburg fire chief stopped fire fighting and evacuated the area until assured by telephone conversation with the Indiana State Fire Marshal that it was safe to proceed with fire fighting, taking due precautions to prevent inhalation of toxic fumes by fire fighters.

fire departments. Unknown to the firemen, approximately 15 tons of fertilizer-grade ammonium nitrate was stored in bags in the first story. Sometime between 7:30 A.M. and 8:00 A.M. the fire had reached the ammonium nitrate as evidenced by change in color of the smoke but it was not until about 9:30 A.M. that the fire chief was told about the ammonium nitrate.

Fifteen tons of fertilizer-grade ammonium nitrate was seriously exposed by fire at Veedersburg, Indiana, on April 11, 1950.

Immediately, the chief ordered all builds ings in the area evacuated, told spectators to get away, and then telephoned the Indiana State Fire Marshal for instructions. The chief was advised that he should be primarily concerned with locating his men so that they would not inhale toxic gases from the decomposing ammonium nitrate. The attack was continued with hose streams, and by 11:00 A.M. the fire had been brought under control.

Farm Storage Building, Dover-Foxcroft, Maine, May 15, 1950

Empty paper bags that had contained 5–10–10 fertilizer were being burned after their contents had been spread on a potato field. Embers ignited the grass, after which fire spread to a 20 ft. by 24 ft. 1-story wooden building where six tons of dolomitic limestone and six tons of fertilizer-grade ammonium nitrate were stored in paper bags. The fire department was called but because of the extent of the fire in the building on arrival they concentrated on controlling the grass fire and preventing its spread to adjacent woodland. (See picture, next page.)

When the farm manager arrived, the building had been destroyed and the ammonium nitrate fertilizer was "bubbling and burning furiously giving off a grayish-whitish smoke." The fire continued to burn for about an hour after he arrived.

Filed under Stables & Barns

Six tons of fertilizer-grade ammonium nitrate (left and foreground) and six tons of limestone (white material) were in a small shed destroyed by fire at Dover-Foxcroft, Maine, May 15, 1950. In the left foreground is a brittle porous mass of ammonium nitrate that had melted and flowed during the fire.

Filed under Fertilizer Works

Fifty tons of bagged fertilizer-grade ammonium nitrate was in this fertilizer mixing and storage building near Lincoln, Nebraska, when it was destroyed by fire on August 8, 1951.

Fertilizer Mixing and Storage, near Lincoln, Nebr., Aug. 8, 1951, $6,000

A 1-story 25 ft. by 60 ft. wooden building and all of its contents, including bagging equipment, 50 tons of bagged fertilizer-grade ammonium nitrate and 150 tons of bagged mixed fertilizer, were destroyed by fire that originated in the yard where used bags and trash were being burned. When an employee saw the fire spread to the building, he tried to put it out with a garden hose. When firemen arrived from Lincoln the combustible building was beyond saving. No explosion occurred as fire fighters drowned the fire with large quantities of water.

Farm Building, near Paola, Kans., March 21, 1953, $600

Approximately six tons of ammonium nitrate was stored in a wooden enclosure within a metal-clad farm building. During a windstorm a small shed was blown over causing overhead wires leading to the metal-clad farm building to short and ignite the wooden fertilizer enclosure.

The farm manager discovered the fire at once, and after being told by the Paola Fire Department that his farm was not in its district, he asked a friend to call a Kansas ammonium nitrate manufacturing plant for advice on how to fight a fire involving ammonium nitrate. The advice was that water was the most effective extinguishing agent and that care should be taken to avoid breathing excessive amounts of the smoke.

Another fire department was then called which responded and with the water carried on apparatus brought the fire under control and confined it to the fertilizer in the wooden enclosure. Although the paper was burned off the bags and some of the ammonium nitrate had decomposed, approximately 80 per cent was useable.

Fertilizer Plant Warehouse, Halls, Tenn., Feb. 16, 1956, $50,000

Short circuit of lead-in wires ignited the outside of the 40 ft. by 100 ft., 1-story wooden warehouse used primarily for bulk storage of inorganic phosphate fertilizer but also containing about nine tons of bagged fertilizer-grade ammonium nitrate. The fire was not discovered until seen by a passing motorist at 12:15 A.M. He notified the police department which drove to the building to verify the existence of the fire before giving the alarm.

Four 2½-inch hose streams were used by Halls and mutual aid companies but due to the extent of fire before their arrival the building was destroyed. During the fire all of the ammonium nitrate was destroyed. There were no explosions but witnesses stated that the fire appeared to burn more brightly where the ammonium nitrate was stored.

Fertilizer Mixing Plant, near Tavares, Fla., Aug. 29, 1956, $207,000

During the night, fire of undetermined cause broke out in the unsprinklered 164 ft. by 96 ft. 1-story, wood-framed building. Discovery was delayed until an employee repairing rolling stock in a detached garage heard crackling of flames at 12:30 A.M.

Dust on structural members from sodium nitrate bagging operations on the preceding day may have accelerated the spread of fire. In any case the structure was well involved wnen volunteer firemen arrived. With no other water available than that contained in the fire apparatus, firemen were unable to put out the fire. No explosions or other unusual circumstances were reported.

At the time of the fire the building contained 329 tons of sewage sludge in bulk, 4 tons of sodium nitrate in bulk, and 81 tons of fertilizer-grade ammonium nitrate, in bags. Net salvage of contents represented about 20 per cent of the total contents value.

Fertilizer Warehouse, Topeka, Kans., Sept. 27, 1956, $2,300

The 50 ft. by 40 ft. 1-story building involved in this fire was wood-framed, had wood sheathing on both sides of wall fram-

Twenty-five tons of bagged fertilizer-grade ammonium nitrate were exposed by fire that originated in a wooden wall of this warehouse at Topeka, Kansas.

ing and had metal sheets attached to the outside of the walls. In one corner of the building 25 tons of fertilizer-grade ammonium nitrate was stored 14 bags high directly against the walls. Bagged super phosphate and several brands of mixed fertilizers were also stored in the building.

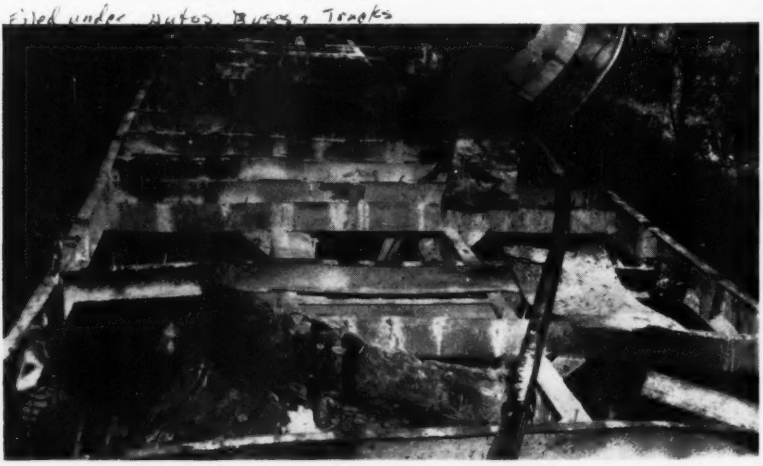
The fire originated in the corner of the building where the ammonium nitrate was stored. It is thought that a spark from a cob burner 100 ft. away lodged behind the metal wall covering and that the fire may have smoldered for some time within the wall before being discovered. Fortunately several companies of firemen were in the neighborhood fighting a grass fire set by the cob burner. They were therefore able to attack the fire minutes after discovery and confine actual fire damage to that corner of the building where the ammonium nitrate was stored.

Behavior of the ammonium nitrate during the fire was as would be expected: a certain amount was decomposed into gaseous oxides of nitrogen, some undoubtedly contributed to the intensity of the fire and some was washed onto the floor and outdoors by hose streams. Otherwise the fire was typical of those in combustible buildings.

Fire in this feed mill elevator at Franklin, Nebraska, did not extend to the basement where fertilizer-grade ammonium nitrate was stored.

Feed Mill, Franklin, Nebr., June 15, 1957

Originating at a feed grinder on the first floor, fire caused considerable damage to the roof, floor, and walls of a 1-story wooden feed mill and also damaged an adjoining grain elevator. An unknown quantity of fertilizer-grade ammonium nitrate was stored in the basement of the mill. Except for a few bags wet by water from hose streams, the fertilizer came through the fire undamaged.



The steel frame was all that remained of a truck trailer containing 17 tons of bulk ammonium nitrate following a fire at Waynesville, Missouri.

Trailer Truck, Waynesville, Mo., Aug. 26, 1957, $10,000

While proceeding slowly uphill a tractor semi-trailer carrying 17 tons of bulk ammonium nitrate was struck in the rear by an empty car transport truck traveling at 75 miles per hour. The driver of the car transport was killed. The underseat gasoline tank of the car transport was broken at the fill pipe and spilled gasoline ignited. An explosion reported by neighbors at time of impact is believed to have involved gasoline vapors.

There is no mention of early fire fighting. When police arrived approximately 25 minutes after the impact, the nitrate trailer and the transport tractor were enveloped in flames and molten ammonium nitrate was dripping from the trailer in a dark mass accompanied by irritating acrid smoke. The wooden trailer bed and the rubber tires provided most of the fuel for the fire.

Trailer Truck, near Memphis, Tenn., April 11, 1958, $3,500

A truck consisting of a 32-ft.-long metal van-type trailer with tractor and containing 320 paper bags (16 tons) of fertilizer-grade ammonium nitrate was pulled to a stop beside the road as soon as the driver realized that one of the rear tires of the trailer was flat. While in a phone booth about 100 yards away calling for help, the driver noticed that the rear left hand tires had burst into flames. After calling the fire department he disconnected the tractor and drove it to safety.

Fire under Fertilizer Bags.

Topic

Fifty tons of ammonium nitrate was in this fertilizer mixing plant when it was destroyed by fire on Sept. 13, 1958.

On arrival, firemen from Whitehaven found that the thin metal deck of the trailer had given way in places and that the tires, the 2- by 6-inch floor boards and the bagged cargo were burning. Molten ammonium nitrate was dripping from the van.

It so happened that the chief of the Whitehaven Fire Department had been given training in fighting ammonium nitrate fires at a fire department training school. He therefore immediately ordered his men to open the rear doors of the van and make holes in the sides to allow the gases to escape, after which booster hoses supplied by water hauled to the scene in tank trucks were directed on the fire. On several occasions the firemen thought they had the fire out only to see the cargo again burst into flame. There were no explosions.

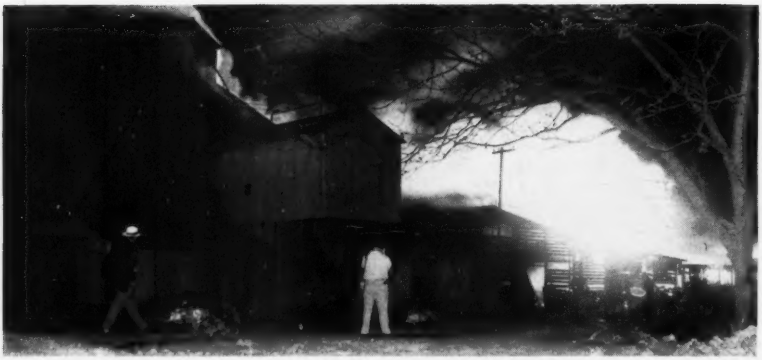
Feed Mill and Plastics Fabricator, Vancouver, Wash., July 14, 1958, $190,000

At 1:20 A.M. a passing motorist noticed flames coming from the roof of a 4-story wooden building housing a feed mill and plastics fabricator. Overheating of a 30 sq. ft. electrically heated vat of wax was the probable cause. The fire was beyond control in the building of origin and in another building 23 feet away when fire fighters arrived.

In addition to several drums of flammable liquids stored in the building of origin there were 40 tons of ammonium nitrate in paper bags. During the fire the only explosions were drums of flammable liquids stored in the plastics fabricators' premises. There was no salvable ammonium nitrate, and in fact the only remains of the fire worth recovering was some scrap steel.

Fertilizer Mixing Plant, Mt. Dora, Fla., Sept. 13, 1958 $200,000

Spontaneous heating and ignition of sewage sludge that in some way became moist (floor seepage or roof leaks) was the probable cause of fire that was beyond control in the 280 ft. by 68 ft. 2-story mixing building when discovered by employees reporting for work. Using five hose streams, firemen did what they could to control the blaze, but because of its extent when they arrived, fire fighting consisted principally of protecting exposed buildings and trucks.



Bill Norment

One hundred and one tons of fertilizer-grade ammonium nitrate were stored in bulk in this fertilizer mixing plant near Lumberton, North Carolina. Locating so that they would not inhale the toxic gases from the decomposing ammonium nitrate, fire fighters followed the recommended procedures of directing hose streams on the piles of ammonium nitrate. No explosion occurred and no fire fighters were injured.

Examination of the 50 tons of ammonium nitrate stored in the building gave no evidence of burning.

Fertilizer Mixing Plant, near Lumberton, N. C., Nov. 19, 1958, $94,000

The main building at this plant was a 1-story wooden structure 200 ft. long by 50 ft. wide. In addition to electric mixing machines in about the center 50 tons of bulk ammonium nitrate were stored about 30 ft. from the mixing machines in one direction and 51 tons stored in bulk in the other direction. Lumberton firemen knew the ammonium nitrate was in the building and also knew that use of water in large quantities was the only effective way to combat fires involving ammonium nitrate.

Responding to an alarm telephoned by a neighbor at 8:30 P.M., Lumberton firemen found flames coming from the roof above the area where the mixing machines were located. Because of the heat from the fire and the reddish brown gases coming from the decomposing ammonium nitrate, firemen were unable to enter the building but were forced to direct hose streams at the piles of nitrate from outside. Nothing unusual happened when the water struck the piles of ammonium nitrate. By taking care not to inhale the smoke no fire fighter suffered injury.

Ten feet from the burning building there was a railroad tank car containing about 36 tons of ammonia solution. Relief valves on the car were operating to relieve excessive pressure before firemen arrived. Hose streams were used to keep the tank cool.

In a fire-resistive warehouse adjacent to the mixing plant 20 tons of fertilizer-grade ammonium nitrate were stored in polyethylene bags. Intense heat caused the polyethylene on the closest bags to melt.

Grain Elevator, Hiawatha, Kans., Dec. 3, 1958

Fire of undetermined origin destroyed the office and elevator warehouse in which approximately 100 tons of fertilizer was stored, including 45 tons of ammonium nitrate in bags. By the time the fire was discovered and firemen were summoned there was no chance of saving the building. They did, however, play water on the fertilizer until the fire eventually went out. During the fire the ammonium nitrate burned intensely but at no time was there an explosion.

Grain Elevator and Warehouse, near Corvallis, Ore., Aug. 23, 1959, $458,500

A group of connected combustible buildings was destroyed by fire that originated in a seed cleaning area on the second floor of a 2-story building. The fire had been burning for some time before discovery by an outsider. This delay, coupled with the delay while hoses were laid from a hydrant 1,250 ft. away and a millpond 1,500 ft. away, allowed the fire to get completely out of hand.

One of the buildings which the fire spread to and destroyed was an 80 ft. by 200 ft.

Gazette-Times

About 5 tons of fertilizer-grade ammonium nitrate was stored in one of the group of buildings destroyed in this fire near Corvallis, Ore., August 23, 1959.

1-story, wood-framed, aluminum-clad building where seed, grain, and about 5 tons of fertilizer-grade ammonium nitrate were stored. Nothing unusual occurred during the destruction of this building and its contents.

Trailer Truck, near Perryton, Texas, Aug. 23, 1959

The driver of a tractor-trailer hauling bagged ammonium nitrate first noticed the odor of diesel fuel in the cab and then discovered flames coming up through the floor boards. He stopped the truck, discharged a portable extinguisher at the visible flames, disconnected the tractor from the trailer and drove it a short distance ahead.

The fire had spread to saddle tanks of diesel fuel by the time firemen arrived. As soon as they learned that the cargo in the trailer was ammonium nitrate ("the same material that blew up the ship in Texas City"), the firemen settled down about 500 yards away to wait for an explosion or the chance to put the fire out. Two hours later, after the fire in the tractor had practically burned itself out, they discharged dry chemical extinguishers and water on the smoking cab.

The trailer was not damaged and after another tractor was obtained, the trailer was hauled to its destination.

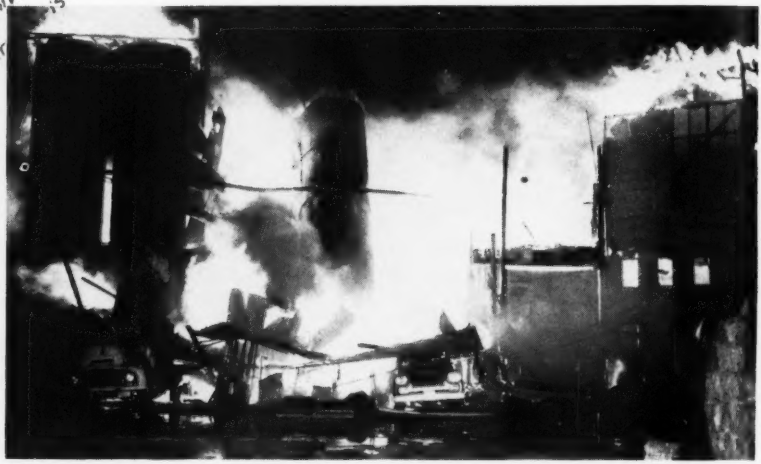
Feed Mill, Medford, Ore., Aug. 28, 1959, $260,000

Two high wooden buildings and a connecting 1-story wooden warehouse were destroyed by fire that originated in a hay grinder. On discovering flames at the grinder, an employee discharged an extinguisher, then ran for a hose. During his absence the fire spread out of control and had entered concealed spaces within walls. The Medford Fire Department placed 10 hose streams in operation but because of the extent of fire by the time apparatus arrived the group of buildings could not be saved.

Approximately 5 tons of fertilizer-grade ammonium nitrate in paper bags was stored in a pile 5 ft. by 10 ft. by 12 ft. high in the 1-story warehouse. Except that the paper bagging was burned off the outside of the pile there was no visible evidence of fire damage to the ammonium nitrate.

Railroad Boxcar, Marysville, Mo. Dec. 7, 1959

Thirty minutes after a boxcar loaded with 1,270 bags (paper) of ammonium nitrate



Dick Simonson

Five tons of bagged ammonium nitrate was stored in a pile on the first floor of one of the buildings destroyed by this fire at Medford, Oregon, August 28, 1959.

arrived at Marysville, the train crew found a hot box on the car, then discovered that there was fire inside the car (steel construction with malleable iron flooring and wood lining).

After drilling a hole through one end of the car, the crew directed a hose stream through the hole and extinguished the fire. On opening the car, the crew found burned and charred wood from the walls of the car, solidified ammonium nitrate, burned paper, and ashes.

Investigators believed that heat from the hot box was sufficient to cause the paper bags or the wood car lining to ignite.

Fire Protection on the Comet 4

By F. A. A. Palmer, A.F.R.Ae.S., G.I. Mech. E.

Aviation Division — Graviner Manufacturing Company

The Comet 4 is now a familiar sight on many of the world's air routes. When it went into service in 1958 it was certainly one of the most thoroughly tested aircraft ever introduced into commercial air transportation. The minute attention to detail which characterized the whole De Havilland effort during the evolution of the aircraft is reflected in the design of the power-plant fire protection systems and of its components. Full scale tests on the ground of all systems vitally affecting airworthiness and safety were applied to the power plant fire protection systems during the rigorous test program conducted in the Ministry of Supply Fire Test Tunnel operated by Rolls Royce at their Flight Development Establishment at Hucknall. In addition, the fire protection equipment was designed, produced, and tested to comply fully with the Airworthiness Requirements of the Air Registration Board in the U.K. and, in most cases, the Federal Aviation Agency in the U. S. A.

This paper describes the Comet's power-plant detection and extinguishing systems and the crash fire prevention equipment installed on the aircraft. On the Comet, two Rolls Royce Avon RA.29 turbine engines are mounted within the inboard section of each wing as shown in the view of an engine installation in Fig. 1.

Each power plant is separated into three fire zones, in two of which both fire detection and extinguishing systems are installed, while in the other, the jet pipe bay, only overheat detection equipment is provided. The provision of an extinguishing system in the jet pipe bay is unnecessary because the only source of overheat is the jet pipe itself. Pipes carrying combustibles are not present in this bay; since the engine is the only source of overheat, failure of the jet pipe will cause a warning to be signaled. Engine shutdown will control the overheat condition by cutting off the supply of high temperature gases.

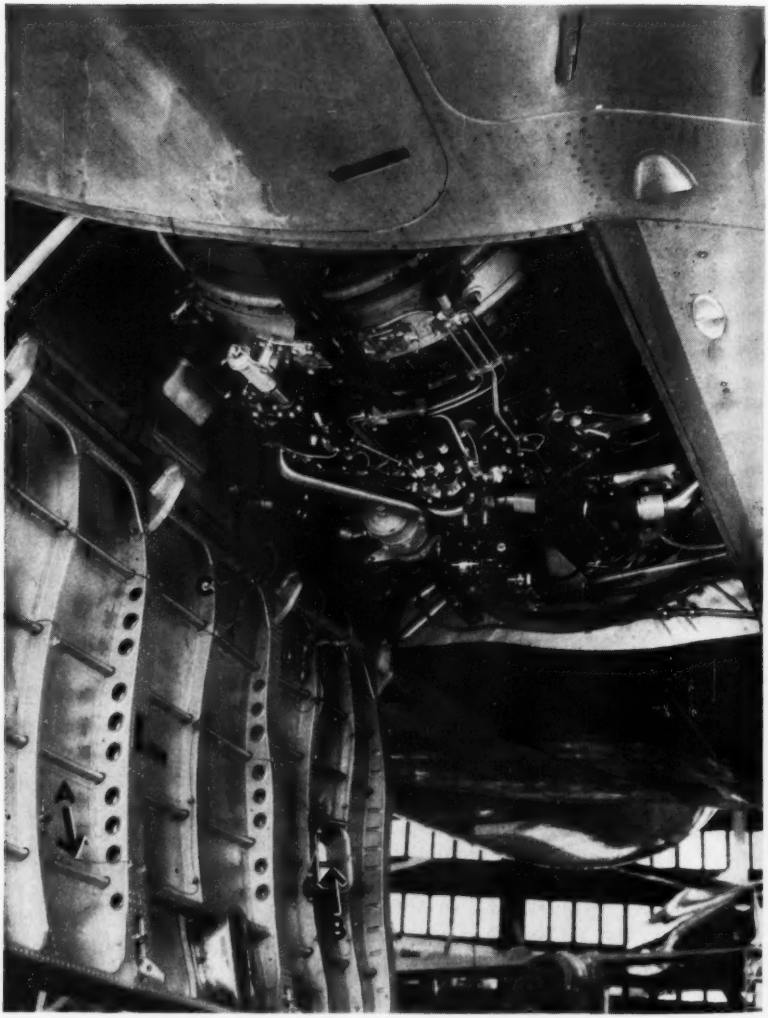


Figure 1. Underside view of one of the Comet 4's Rolls Royce Avon RA. 29 turbine engines. In the Comets, the power plants are mounted in the wing while in most U. S. commercial jet transports the engines are suspended in "pods" beneath the wings. On the access door is mounted part of the FIREWIRE detection circuit (Arrow A) and at Arrow B one of the unit detectors (temperature-sensitive switches). Arrow C points to the flexible connectors for the continuous detector circuit. (See Figure 2 for diagram of components.)

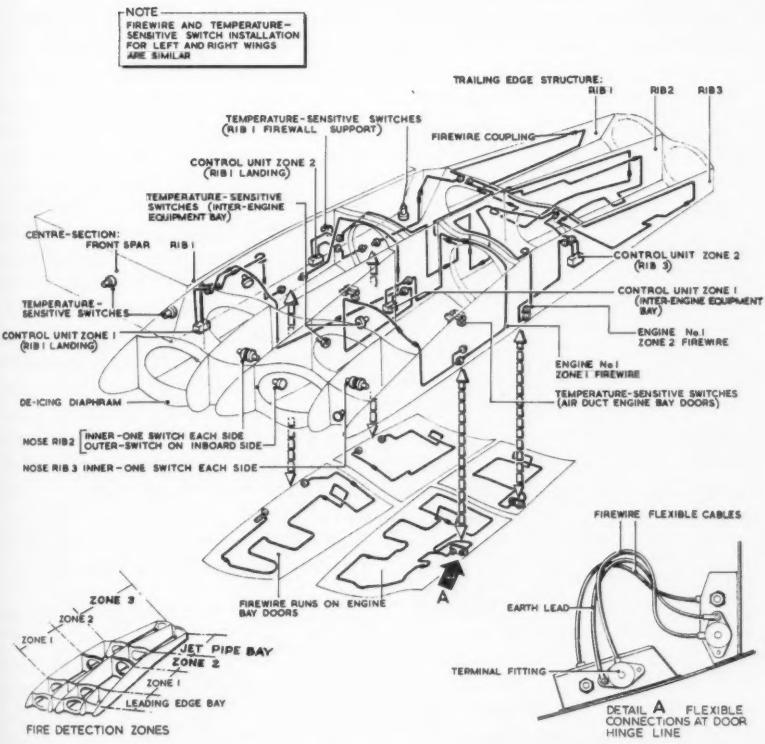

NOTE
FIREWIRE AND TEMPERATURE-SENSITIVE SWITCH INSTALLATION FOR LEFT AND RIGHT WINGS ARE SIMILAR
TRAILING EDGE STRUCTURE:
RIB 1
RIB 2
RIB 3
TEMPERATURE-SENSITIVE SWITCHES (RIB 1 FIREWALL SUPPORT)
FIREWIRE COUPLING
CONTROL UNIT ZONE 2 (RIB 1 LANDING)
TEMPERATURE-SENSITIVE SWITCHES (INTER-ENGINE EQUIPMENT BAY)
CENTRE-SECTION: FRONT SPAR
RIB 1
CONTROL UNIT ZONE 2 (RIB 3)
CONTROL UNIT ZONE 1 (INTER-ENGINE EQUIPMENT BAY)
TEMPERATURE-SENSITIVE SWITCHES
CONTROL UNIT ZONE 1 (RIB 1 LANDING)
ENGINE No.1 ZONE 2 FIREWIRE
ENGINE No.1 ZONE 1 FIREWIRE
TEMPERATURE-SENSITIVE SWITCHES (AIR DUCT ENGINE BAY DOORS)
DE-ICING DIAPHRAM
NOSE RIB 2 INNER-ONE SWITCH EACH SIDE OUTER-SWITCH ON INBOARD SIDE
NOSE RIB 3 INNER-ONE SWITCH EACH SIDE
FIREWIRE RUNS ON ENGINE BAY DOORS
A
FIREWIRE FLEXIBLE CABLES
EARTH LEAD
TERMINAL FITTING
DETAIL A FLEXIBLE CONNECTIONS AT DOOR HINGE LINE
ZONE 3
ZONE 2
ZONE 1
JET PIPE BAY
ZONE 2
ZONE 1
LEADING EDGE BAY
FIRE DETECTION ZONES

Figure 2. The Rolls Royce turbine engines on the Comet 4 are mounted in pairs on the port and starboard sides. This diagram illustrates the placement of the port engines and shows the fire detection system layout. Note that the system is composed of both a continuous type and a unit type detector (temperature-sensitive switches). In the lower left hand corner, the layout of the segregated fire zones is shown while in the lower right hand corner, the flexible connections for the continuous detectors at the access doors are illustrated. The term "earth wire" is referred to as "ground wire" in U. S. practice. (See Figure 1 for a further illustration of the components.)

The layout of the fire zones is shown in the bottom sketch in Fig. 2. Zone 1 (containing the compressor section) is effectively enclosed by wing ribs 1 and 2 (inboard engine) or wing ribs 2 and 3 (outboard engine), the upper wing skin and the engine access doors on the lower wing surface. Within fire zones 1 and 2, wing rib 2 is fabricated from stainless steel and ribs 1 and 3 are shrouded for fire resistance with titanium. The rear face of the front spar and a stainless steel fire wall between the engine compressor (Zone 1) and combustion section (Zone 2) provide lateral fire resistant segregation between the wing ribs.

Zone 2 (containing the combustion section) extends from the rear face of the interzone fire wall of the engine to a titanium fire wall in front of the rear wing spar.

Zone 3, the jet pipe bay, in which (as previously mentioned) only overheat detection is provided, extends from the

rear face of the rear Zone 2 fire wall to the jet nozzles at the rear of the trailing edge wing section. Within Zone 3, rib 1 is shrouded with titanium while the trailing edge of both ribs 2 and 3 is of light alloy as this is not a classified fire zone.

Fire and Overheat Systems

The primary fire detection system in each power plant is provided by the GRAVINER "FIREWIRE" continuous detector. In Zone 1, this continuous fire detection system is augmented by an auxiliary system of GRAVINER unit type temperature sensitive detectors.

Fire detection is also provided for by additional unit detectors (temperature-sensitive switches) in the center section front bay and the space between ribs 1 (port and starboard sides) and their fire walls. In this space are high temperature deicing and fuel piping. Temperature-sensitive switches are also fitted adjacent to and within the Zone 1 ventilating air outlet. The schematic layout of the complete fire and overheat detection systems is given in Fig. 2.

The "FIREWIRE" detecting elements within each engine bay are entirely airframe mounted and arranged so that those elements mounted on the engine access doors can be removed with the doors by detachment of flexible cables across the door hinge (see Detail A in Figure 2).

Completely segregated warning systems are provided for Zone 1 and for Zones 2 and 3 together. These systems are connected to separate control units providing means to indicate in the cockpit from which of the two segregated sections of the power plant the warning originates. The temperature sensitive switches in Zone 1 are electrically in parallel with the Zone 1 "FIREWIRE" fire detection system.

Design of Continuous Detector

The "FIREWIRE" element consists of a stainless steel capillary 0.077 inches in diameter through which is run coaxially a wire surrounded by a highly compressed temperature-sensitive material. The assembly thus formed is then a strong, flexible, steel-covered cable with the essential characteristic of having a material between the center wire and the inner walls of the capillary whose electrical resistance varies inversely and logarithmically with temperature. The application of an electrical potential to the center wire will therefore cause a current to flow between it and the capillary, and the magnitude of this current will depend upon the length of the cable and the temperature to which it is heated. Fig. 3 gives a typical plot of temperature against current and shows the bands within which fire de-

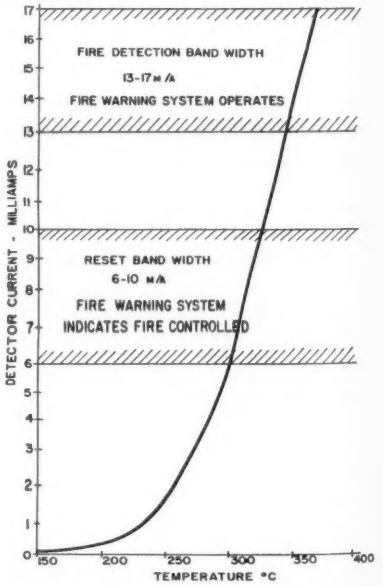


Figure 3. The GRAVINER "FIREWIRE" temperature-current relationship is illustrated showing the fire detection band and the reset band as explained in the text.

tection and cancellation are signaled by the control unit.

Coaxial plugs of a design capable of withstanding exceptionally high temperatures for long periods are permanently attached to each end of the element, and these, with the use of suitable interconnectors, permit the build-up of almost any desired length of element for each control unit. Fig. 4 is a cross section of two "FIREWIRE" end fittings mated with one of two types of interconnector. The ceramic seal assembly in each end fitting will withstand continuously temperatures up to 400°C (752°F) and temperatures higher than this for shorter periods. Operation of the system is unimpaired after complete immersion of the end fitting assembly or any portion of the element in an 1100°C (2012°F) flame for a period of 15 minutes. The detecting element itself will function quite normally after complete immersion in an 1100°C (2012°F) flame for many hours and although it will never be required to endure this treatment in service it serves to illustrate the stability of the temperature-sensitive material used.

The elements will also function quite normally after such extreme maltreatment as being crushed to the thickness of only the center wire. This degree of damage is unlikely in service but illustrates important durability characteristics of the system.

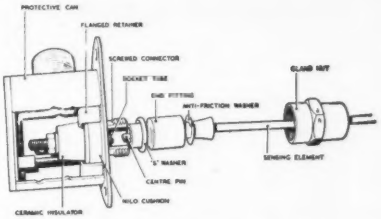


Figure 5. A section drawing of a bulkhead fitting and an exploded view of the "FIREWIRE" end fitting.

Bulkhead and termination fittings, again incorporating the feature of hermetical sealing within the body of the fitting, serve to terminate each end of the system at the limit of and in some cases within the fire zone and to provide connections to the control unit via normal electrical cabling. Fig. 5 gives a section through a connected "FIREWIRE" element and bulkhead fitting.

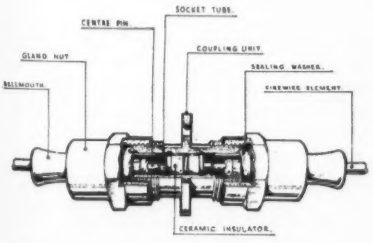


Figure 4. Detector reliability is greatly influenced by the integrity of the continuous type detectors used in the Comet 4. This shows a cross section of the interconnection of "FIREWIRE" sensing elements in one of two types of interconnectors used in the Comet 4.

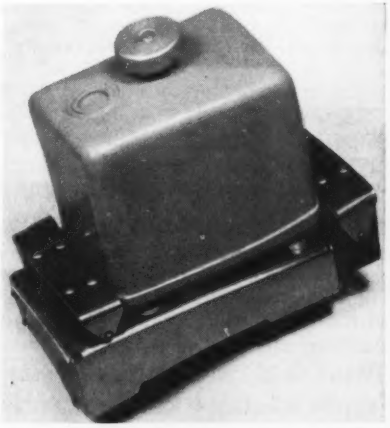


Figure 6A. The detector control unit consists of two parts so designed that the electrical components (mounted in the top unit) can be replaced without disturbing any of the electrical cables mounted in the power plants. (See Figure 6B for further details.)

Detector Control Unit

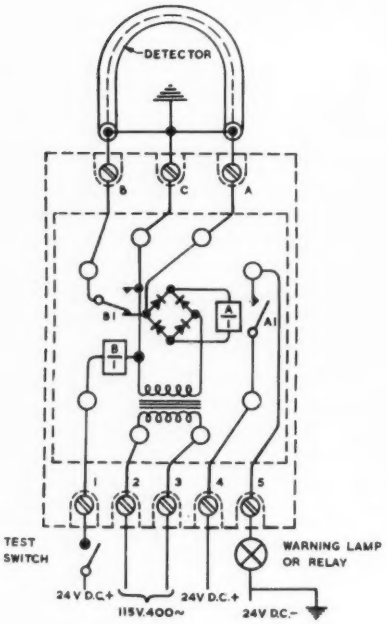


Figure 6B. The electrical circuit diagram for the detector control unit. B/1 is the test relay coil and B1 the associated contacts. A/1 is the detector relay and A1 the associated contacts.

The control unit is designed to give simplicity, ruggedness, and ease of servicing. Fig. 6A illustrates the assembly of the two component parts of the unit. The base unit serves to terminate aircraft electrical supplies and remains permanently attached to the aircraft. The center of the base unit is provided with a moulding carrying eight spring loaded plungers connected to the terminals on the two terminal blocks. The top assembly is called the "relay unit."

Fig. 6B shows electrical components mounted in the relay unit within a resin potted container having eight contact buttons at its base and a retaining screw passing down the center. The retaining screw mates with a locknut in the base unit and when tightened causes the button contacts to mate with the base unit spring plungers. Aligning pins on the relay unit prevent incorrect assembly. In service the relay unit can be changed in less than one minute without any of the electrical cables having to be disturbed.

Operation of Detection System

It should be clearly understood that both the "FIREWIRE" system and the temperature-sensitive switches will function either in fire or overheat conditions. There is, however, no differentiation in the cockpit between a warning due to an overheat condition, such as a hot air leak or hot gas leak, and a fire in either Zone 1 or Zone 2.

The principal reason for this is that since engine shutdown is the first essential action of the fire drill, if an overheat condition caused the warning then removal of the source will cancel the warning before extinguishing action is necessary. This is a feature of all British fire protection system design and achieves the object of keeping the pilot's display as simple as possible. A simple and straightforward fire drill is also possible. In fact simplicity forms a basic criterion of both fire system and component design.

In operation the complete "FIREWIRE" system receives 115 volts 400 cycles per second (cps) power at the control unit from the aircraft supply. The step-down transformer within the control unit places a 26 volt 400 cps potential across the center conductor and sheath of the "FIREWIRE" from both ends of the element system.

Under normal operating conditions in the Comet, power-plant ambient temperatures within each zone are insufficient to cause an appreciable change

Figure 7. A general view of the Comet 4 cockpit. The test panel for the fire warning system is just off the figure on the extreme right at the Flight Engineer's position. The fire warning panel is over the center windshield as marked by arrow (see Figure 8A for a view of the fire test switches and Figures 8B and C for a clearer picture of the pilot's fire warning panel).

in the normally high resistance between the center conductor and the stainless steel sheath and in consepuence the current flow through the detector and the relay-rectifier network in the control unit is negligible. Should fire or overheat occur in any part of Zones 1, 2, or 3, a sharp drop in resistance across the "FIREWIRE" element will occur and when the current flow has increased to between 13 and 17 milliamps a detector relay will operate and cause a warning to be given on the pilot's fire panel in the cockpit and a warning bell to sound. There is also a primary warning lamp on the pilot's center pedestal which is illuminated on the receipt of an engine fire warning. Pilot's fire drill is then carried out (see page 245).

Reset Feature

When the fire or overheat condition has been controlled the temperature within the zone concerned will fall and with it the temperature of the "FIREWIRE" elements. The current flow in the detector elements will also decrease as the temperature decreases and when a current flow of between 6 and 10 milliamps is reached the detector relay will reset and cause a cancellation of the warning light on the cockpit fire warning panel. The primary warning lamp is then reset by manual operation of a switch on the services test panel (Fig. 8A).

Testing Means

Complete "FIREWIRE" system circuit test arrangements are provided for preflight or inflight testing of each system. Operation of test switches at the aircraft flight engineer's position (Fig. 8A) indicates integrity of all engine and wing bay systems by lighting both the

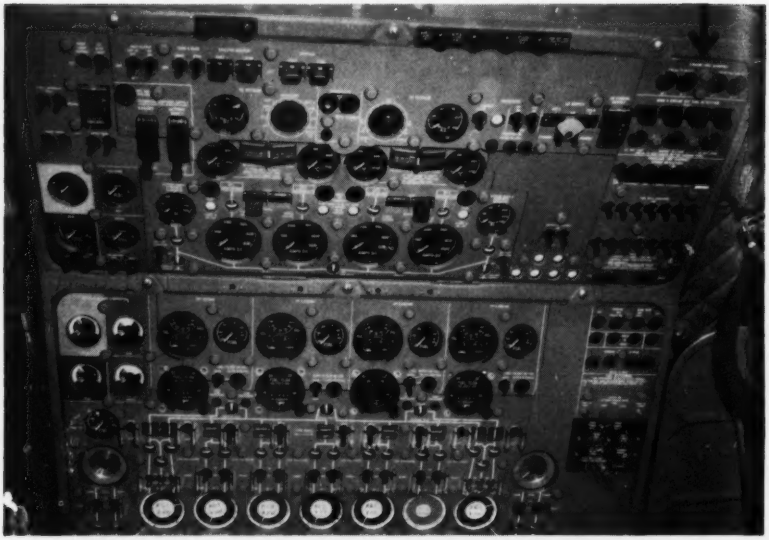


Figure 8A. The fire warning test panel is at the upper right hand corner on the Flight Engineer's panel as indicated by arrow.

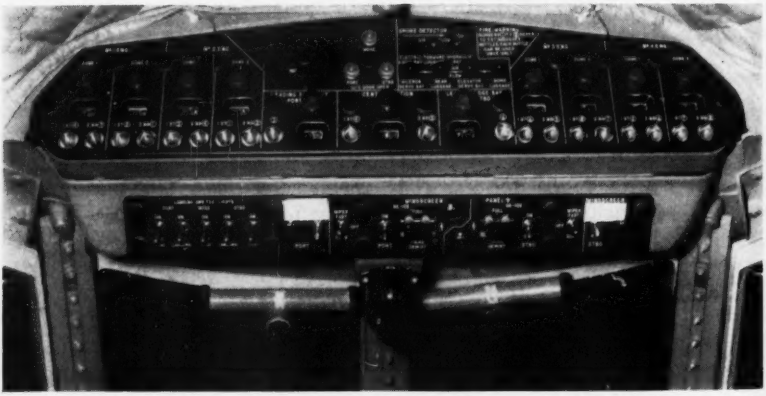


Figure 8B. The fire warning panel directly above the center windshield. (See Figure 7 to orient position of panel on pilot's instrument array.)

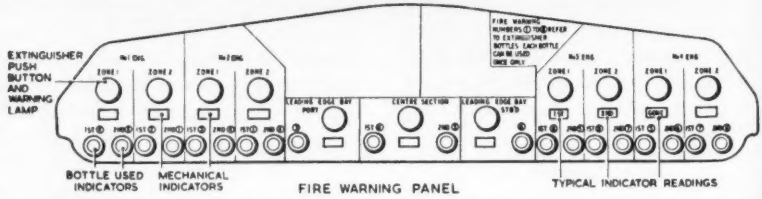


Figure 8C. This diagram identifies the components of the fire warning panel photographed in Figure 8B.

appropriate warning lamp on the indicating panel immediately above and between the pilot's and the primary warning lamp on the pilot's center pedestal. The layout of the pilot's fire warning panel is shown in Figs. 7, 8B, and 8C.

During circuit test of the "FIREWIRE" system, operation of the appropriate test switch in the cockpit will cause operation of the test relay in the control unit (Figs. 6A, 6B). This reorientates the power supplies within the control unit placing the center conductor of the "FIREWIRE" elements in series with the 26 volts 400 cps supply. The center wire resistance is low enough to simulate the resistance level that exists during a fire or overheat condition and this allows sufficient current to flow in the detector relay to cause operation. DC power is then supplied to the primary warning lamp on the pilot's center pedestal, the appropriate warning lamp on the pilot's fire warning panel, and to a warning bell. Cancellation of the warning lights after test is facilitated by reset push buttons on the systems test panel. Operation of the reset button causes reset of both the test and detector relays in the control unit.

Operation of a push button on the systems test panel tests the integrity of the electrical system associated with the temperature-sensitive switches in the port and starboard leading edge bays and the center section bays.

Unit Detector Design

The temperature-sensitive unit detectors (Fig. 9A) used are of a design proven by hundreds of thousands of flying hours in many types of civil and military aircraft. Referring to Fig. 9B, it will be seen that the operative section of the unit, the barrel assembly, comprises an alloy steel tube closed at both ends containing a spring bow assembly

Figure 9A. The exterior view of the temperature sensitive unit detectors used on the Comet 4 for fire and overheat warning.

upon which are mounted two silver rhodium contacts. The contacts are connected to the terminal head assembly by fire-resistant cable.

Increase of temperature of the barrel, the material of which has a high coefficient of expansion, results in a relaxation of the compressive force exerted on the low coefficient of expansion spring bow assembly. At a preset temperature, therefore, the contacts will close and the warning system will operate. Decrease of temperature will allow the contacts to open again and the warning to cancel.

In the Comet, the detectors are set to operate at temperatures of 230°C (446°F) in the wing leading edge, the center section front bay, and on the Zone 1 engine access doors. Detectors set at 400°C (752°F) are positioned in the engine compressor seal vent and in the engine rear bearing cooling air out-

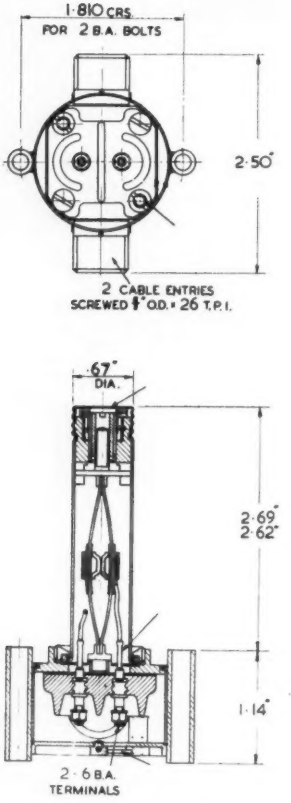


Figure 9B. A sectional view of the unit detectors which are set to operate in accordance with placement in the various fire zones on the Comet 4.

let. The wheelcase breather outlet is monitored by a detector set at 330°C (626°F). The rear bearing, compressor seal vent, and wheelcase breather detectors form an engine failure detection system which has a separate warning lamp on the cockpit center instrument panel and is not integrated with the fire warning system.

Power-Plant Fire Extinguishing System

The layout of the fire extinguishing system for the power plants is illustrated in Fig. 10 from which it will be seen that the discharge system is composed of both spray pipes and nozzles. This combination was evolved during the full scale fire testing when its effectiveness was satisfactorily demonstrated.

Extinguishing Agent Containers

The complete aircraft system utilizes eight methyl bromide fire extinguishers of two distinct types. Methyl bromide, although toxic, is still one of the most efficient fire extinguishants known and, providing due consideration is given to this property during agent container design and subsequent positioning in the aircraft, is completely safe.

The extinguishers are located outside the pressure cabin so that even accidental leakage of the agent could not possibly penetrate the cabin. Maintenance procedures are such that there is no risk to personnel during servicing operations.

Four are GRAVINER Type 71A triple outlet head extinguishers, of a type specially developed for the Comet systems with the prime object of keeping system weight to an absolute minimum and obtaining the greatest flexibility of extinguishant distribution This extinguisher and the method of mounting in the Comet is illustrated in Figs. 11A and 11B.

The remaining four are GRAVINER Type 62A dual outlet head extinguishers. Both types of extinguishers contain twelve pounds of methyl bromide and are pressurized with dry nitrogen. The total quantity of extinguishing agent is thus 96 pounds.

Each of these extinguishers will discharge its entire contents through any one head upon operation of the appropriate push button in the cockpit. Extinguisher contents availability is, however, arranged so that a first and

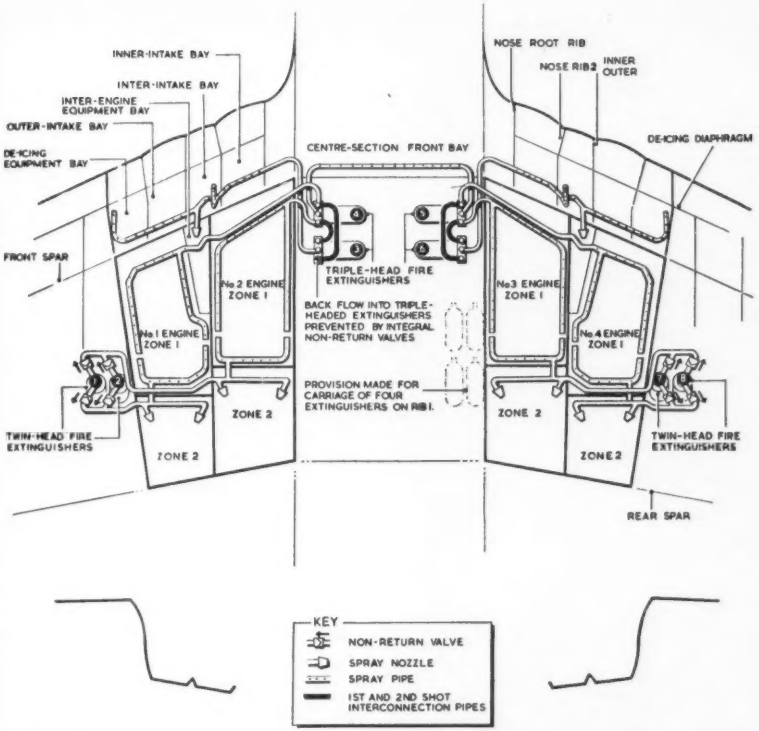


Figure 10. The power plant and wing fire extinguishing systems have both spray pipes and nozzles as illustrated to cover the fire zones protected. There are eight methyl bromide fire extinguishers supplying a total of 96 pounds of extinguishing agent. The text describes the operation of the equipment.

second shot from different extinguishers is available for each fire zone protected except that the leading edge bays can receive one shot only. The method of achieving this is clearly shown by reference to Fig. 10.

The choice of a cylindrical container rather than spherical follows mainly from consideration of the installation problems in modern aircraft. It is felt that the slight weight advantage due to the theoretically greater strength/weight ratio of the spherical container is outweighed by the wider choice of mounting positions offered by the cylindrical form.

The crash case also has some bearing on extinguishant container geometry and desirability of a cylindrical rather than spherical container. It is essential to maintain a submerged outlet during the low inertia loadings experienced during the initial phases of some accidents when it is required to actuate the fire suppression systems in order that the system discharge characteristics remain completely effective.

The container of both extinguishers is a one piece deep drawn copper shell to which the operating head is screwed and soldered. The operating head of all GRAVINER extinguishers incorporates

Figure 11A. There are four of these type 71A triple outlet head extinguishers especially developed for the Comet.

the same basic design of discharge system.

Referring to Fig. 12, the one piece head stamping has fine machined integral diaphragms the thickness of which is very closely controlled during manufacture. On the outer face of the diaphragm and integral with it is a threaded central pillar to which is attached the charge plug. When this is assembled it will be seen that a small annular chamber exists adjacent to a small port which is in line with the center of the cartridge unit attachment flange.

The fluid discharge junction assembly forming the means of attachment of the aircraft system is also screwed to the head of the extinguisher.

Extinguishing Agent Discharge

The extinguisher operating cartridges are mounted on the seatings provided on the head of the extinguisher and are shown in the photo in Fig. 13. Completion of the 24 volt DC power supply circuit to the pins of the cartridges energizes a light fusewire in the charge holder. This in turn causes very rapid burning of the gunpowder charge surrounding the fuse, and the very sudden increase of pressure in the annulus below the diaphragm is sufficient to rupture the diaphragm and drive the charge plug to the bottom of the junction box thus allowing the methyl bromide to discharge into the aircraft system under the 250 lbs./sq. in. nitrogen pressure in the container. When the charge plug reaches the bottom of the junction box, a small pin is pushed through the screwed cap, this, then, serving to give external indication that the extinguisher has been discharged.

The head of the extinguisher also incorporates a platinum pressure relief disc which will fracture and relieve the contents overboard if overheat of the extinguisher occurs.

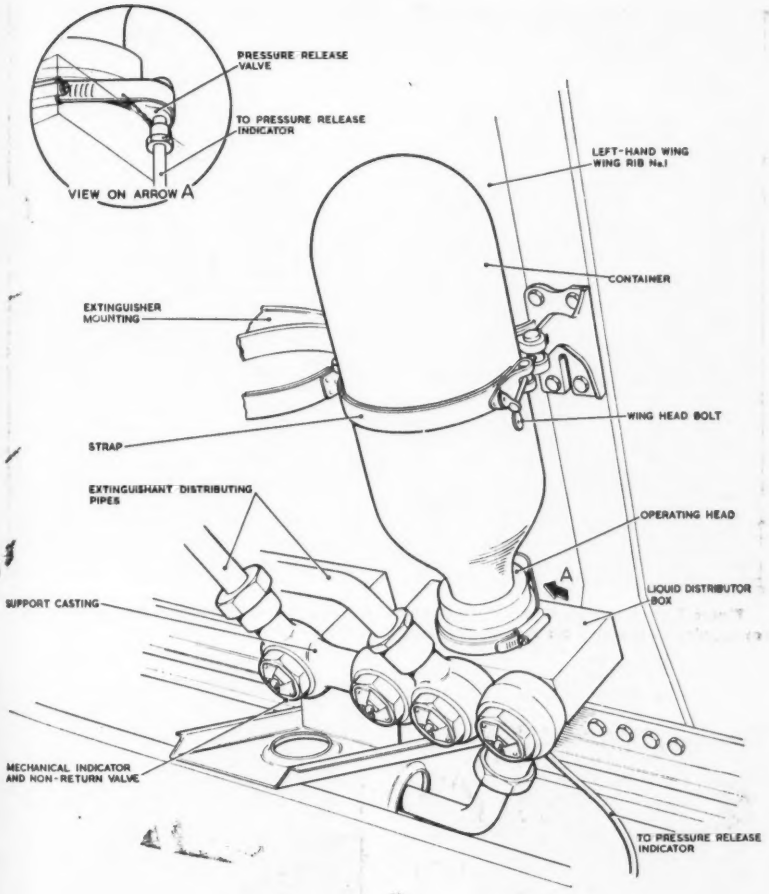


Figure 11B. A typical mounting of one of the methyl bromide extinguishers in the Comet 4. These extinguishers are located outside of the pressurized cabin so that even accidental leakage of the agent could not penetrate occupied portions of the aircraft.

Should pressure relief of any extinguisher occur, a small disc, colored green, and snapped into the body of the discharge indicator (Fig. 14) is ejected by the discharging methyl bromide. The exposed face of the indicator is colored red. The indicator body is mounted on the underwing skin so that during preflight inspection the integrity of the extinguishers with respect to possible pressure relief can readily be checked.

With this design the number of mechanically seating seals in the extinguisher is reduced to an absolute minimum and this is considered an essential

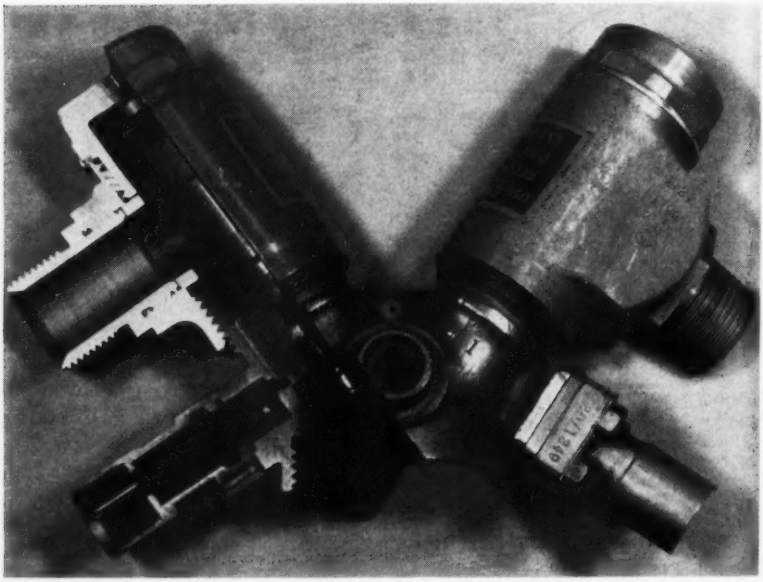


Figure 12. A part sectional view of one of the dual head GRAVINER methyl bromide extinguishers showing the cartridge actuator (see Figure 13 for cartridge unit).

Figure 13. One of the extinguisher operating cartridges. The fuse wire in these cartridges is operated electrically and when such operation takes place, the methyl bromide is discharged into the aircraft system under a pressure of 250 psi.

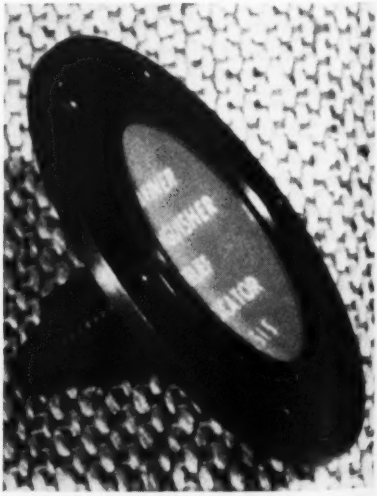


Figure 14. This is the indicator mounted on the underwing skin to readily observe the integrity of the extinguishing system. If operated the exposed surface of the indicator is colored red whereas normally it is green.

design point on any such pressurized container for use during emergency conditions.

The triple discharge head extinguisher incorporates three separate discharge ports but differs from the standard extinguishers in that the gunpowder charge is actually built into the annular chamber below each diaphragm. Functionally the two extinguishers are similar.

Cockpit Fire Warning Panel

Before consideration of the fire drill followed upon receipt of a warning, mention should be made of the cockpit fire warning panel which is of a unique design both in layout and the components used.

Each fire zone has its own warning light, although, as previously mentioned, Zone 3, which receives no extinguishant, is included with the Zone 2 warning on the fire control panel.

The warning lights (Figs. 8B and 8C) also serve as the fire extinguishant discharge buttons. Integral with and below each combined light and push button is a mechanical indicator, also operated by the push button. Below the mechanical indicator are situated discharge indicator fuses which operate when electrical energization of the respective extinguishers has taken place. These serve to present to the pilot a clear indication of what extinguishant he has available for each engine and are a valuable preflight indication that the extinguisher is in the correct standby state for flight. Should inadvertent operation of an extinguisher occur during servicing, it will be immediately obvious to the crew.

During normal operation the mechanical indicator will show "1ST" and the two indicator fuses will not be discolored. Upon receiving a fire warning, when the pilot presses the appropriate combined extinguisher button/light, the mechanical indicator changes to "2ND" and the first shot indicator fuse bulb will change from clear to red. When the button is pressed a second time, the mechanical indicator will read "GONE" and the second shot indicator fuse bulb will also discolor red.

The discharge indicator is a pyrotechnic device, consisting of a metal body or fuseholder within which is retained a small removable bulb containing a match head fuse and electrical resistance wire. The fuse is placed electrically in parallel with the extinguisher firing line so that it will be energized at the same time as the extinguisher button is pressed. When energized, the normally clear inner face of the glass bulb of the fuse is immediately covered with a red powder and thus remains permanently discolored. The pilot therefore can see clearly that the first or second shot, as the case may be, has been used and the ground crew will know immediately on check that the appropriate extinguisher has been operated.

Power Plant Fire Drill

The following sequence of operations is carried out if a fire warning is received on either the Zone 1 or the combined Zone 2 and 3 warning systems.

1. High pressure fuel cock — OFF.
2. Low pressure fuel cock — OFF.
3. Illuminated fire extinguisher discharge buttons — PUSH to discharge "1ST" shot.
4. Generator — switch to TEST (OFF) and check loads on remaining generators.
5. Cabin pressure supply lever — OFF.
6. Illuminated fire extinguisher button if still illuminated after "1ST" shot — PUSH to discharge "2ND" shot.

Similar procedures apply to other fire zones, except that the leading edge bays have only one shot available.

In the case of internal engine overheat, the engine failure warning lamp on the center instrument panel is illuminated by operation of any one of the associated temperature sensitive switches and the engine is shut down. The extinguishing system associated with that engine is not operated.

Crash Fire Prevention

The Comet also has crash fire prevention principles applied fully in both the power plant and other parts of the aircraft for which fire extinguishant is carried.

It is contended that the British Civil Airworthiness requirements, properly implemented, provide an essential contribution to safety during the remote, but nevertheless real, possibility of a crash.

In any aircraft crash in which the aircraft has alighted without major structural failure it is probable that the majority of the occupants have suffered nothing worse than a shaking and possibly shock. There is also no doubt that in any successfully completed wheels-up emergency landing on land there is still quite a high probability of fire which alone can quickly destroy the aircraft and/or hinder successful attempts at rescue.

Under these circumstances, since the aircraft is already carrying considerable quantities of extinguishant for in-flight fire risks, it is thought to be safer and it is most certainly logical to provide for the dispersal of this fluid to the maximum advantage by a well designed crash system. Similarly the isolation of other serious potential sources of ignition, such as the generators and battery, is accomplished together with the shutting-off of the high pressure fuel supply to the engines.

The crash system utilizes GRAVINER initiating devices actuated both by decelerations exceeding 3g along the longitudinal axis of the fuselage and by deflection on impact with the ground.

Crash Inertia and Deflection Switches

Operating of the inertia switches which are series connected, will discharge all fire extinguishers and isolate the electrical power supply but will not shut off the fuel supply to the engines. Operation of the deflection switches will shut off the high pressure fuel supply by an interconnected mechanical linkage system and will, in addition and independently, operate the extinguishers and isolate the electrical system.

The inertia switches are positioned on the roof of the nose landing gear well and the deflection switches are in each wing section at rib 2.

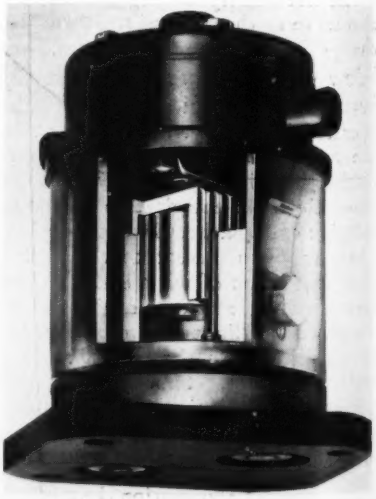


Figure 15. The GRAVINER Inertia Crash Switch Type 8C designed to operate at 3g. It is primarily designed for operating fire protection equipment and other electrically operated devices to reduce crash fire ignition sources.

The GRAVINER Inertia Switch Type 8C (Fig. 15) is a unidirectional single pole switch designed to operate at 3g when applied as a forward component only along the polar axis of the switch and is intended primarily for operation of fire protection equipment and other electrically operated aids to survival under crash conditions.

The switch comprises an inertia element consisting of a highly finished Monel cylinder carrying an externally fluted Monel piston trip weight, fitted with an internal dynamic damping slug. A bowed spring located over the open end of the cylinder bears on the piston crown so that piston movement can only occur when the resistance of the spring is overcome. The "g" settings of the switch are obtained by variation of the bowed spring compression, and when the resistance is overcome by the inertia of the piston, the bow snaps over into reverse curvature and bridges a pair of leaf contacts. The contact terminals are moulded into a waterproof bakelite terminal block which also carries a reset plunger to enable the switch to be reset after calibration check, or rough handling during transit. The entire element is built on a light alloy cylinder block, which is sealed in a transparent cylindrical case, the whole being attached to a flange which has four mounting holes. The switch is designed to pass 2 amps at 28 volts.

The GRAVINER Deflection Switch Type 9C is illustrated in Fig. 16. It is designed to operate aircraft extinguishing systems and electrical isolation circuits by sensing physical deflection at some strategic point of the aircraft structure. By utilizing both mechanical deflection and inertia sensing types in one system, virtually all survivable crash configurations and accelerations are covered. Similarly in the extremely unlikely event of in-

Figure 16. The GRAVINER Deflection Switch Type 9C is a companion unit as explained in the text to the Inertia Crash Switch illustrated in Figure 15. While the Inertia Switch will discharge extinguishing agent and isolate the electrical power supply, it will not shut off the fuel supply. The operation of this Deflection Switch is necessary to shut off the fuel supply and is capable of independently operating the extinguishers and isolating the electrical system.

flight accelerations causing operation of the inertia switches, cutoff of those systems essential to flight cannot occur until the deflection switches have also operated.

The operating rod, which, in the Comet, is connected by linkwork to a lever protruding from the aircraft undersurface at wing rib 2, will be pulled outwards from the switch body when operated. As the sleeve attached to the operating rod passes over the two inner balls on the central plunger assembly, the balls are forced outwards

by the spring pressure on the central plunger. The plunger then moves freely to the opposite end of the switch and bridges electrical contacts in the terminal block assembly. The spring loaded ball in the body of the switch prevents manual reset of the switch until the terminal cover is removed and the central plunger is depressed in conjunction with return of the operating rod to its normal position.

The crash deflection lever which, as previously mentioned protrudes from the under surface of the wing, has a steel knife-edged pocket covering it to prevent inadvertent operation during ground handling and by contact with birds in flight. This cover has been demonstrated to be fully satisfactory after contact with a 4 lb. bird at 400 knots neatly sliced the bird in two.

In the two cases so far of crash landings during which the crash system was operated, one of which was a Comet 1, the complete system operated perfectly and it is not without significance that *no* fire occurred after the crash in either case. Only two of the 59 occupants in the one Comet 4 crash lost their lives and this in a crash of great severity in which a longitudinal deceleration greater than 8g was experienced with an aircraft whose fuel tanks were already heavily damaged by the first impact. It is thus possible that the occupants of the aircraft owe their lives to the careful thought and design effort put into the Comet crash protection systems and equipment.

Fire Testing

The Comet power plants were fully fire tested by Rolls Royce in their fire test tunnel and during an exhaustive series of tests, including some sixty fires, the fire protection equipment was found fully satisfactory.

Analysis of the complete details of the Comet 4 fire test program lead to the conclusion that the airborne safety of the aircraft from engine fire hazards is highly satisfactory.

The author would like to acknowledge the assistance given during the preparation of this article by The De Havilland Aircraft Company Limited and Rolls Royce Limited and in particular Mr. F. I. Marking and Mr. J. N. Dent of De Havilland and Rolls Royce respectively. His task was essentially to collate the available information and present it in a form suitable for assimilation by the reader who may be unfamiliar with aircraft fire protection design practices.

It is not possible to acknowledge fully the efforts of the many individuals who contributed to the evolution of the Comet 4 systems and components but it should be emphasized that the credit is due to many rather than few.

The author also wishes to thank the Graviner Manufacturing Company Limited for the permission to publish the article.

Specialized Education in Fire Safety

By Joseph M. Chase, Flight Safety Foundation

Chairman, NFPA Sectional Committee on Aircraft Maintenance and Servicing

An attack on the fire problems in any industry requires knowledge of the basic fire hazard possibilities of the industrial processes involved. The education of employees is best directed if it attacks particular problems. Even this may fall on disinterested ears unless the educational campaign is dramatized by use of fire experience.

Fire stories which illustrate the importance of certain prevention techniques and protection requirements are not easy to collect. The NFPA QUARTERLY has published masses of material of this nature for this purpose during the fifty-two years of its existence and has become a standard reference source to many members who find it convenient to use this published material to arouse employee or management interest in fire prevention or protection. This is as it should be, and the NFPA naturally takes delight in such effective use of the material.

The Flight Safety Foundation publishes and disseminates such information for the benefit of its specialized audience. The Foundation's *Mechanics Bulletin* reports on aircraft fires, their causes and cures, to encourage proper maintenance procedures and to educate on fire control techniques.

Neither the NFPA QUARTERLY nor the FSF *Mechanics Bulletin* reaches all who should be concerned and interested, nor do we expect that those *not* holding direct fire safety responsibilities would have sufficient interest to read these publications. For this reason, other magazines and "house organs" are encouraged by both organizations to develop and print constructive material dedicated to fire safety purposes.

This B–47 went out of control on take off at a speed of 70 knots because a mechanic had left a socket wrench in the forward main gear (see photo next page). When the gear collapsed, the fuel lines were ruptured, and a forward cell split, resulting in total destruction by fire and one fatality.

The purpose of this particular article is to show how one magazine covered in one issue a number of significant fire stories, all slanted to the specialized audience which was theirs. The magazine, *Aircraft Accident and Maintenance Review*, is published by the Department of the Air Force, the Inspector General USAF, and is sold to the public on subscription ($3.00 per year) through the Superintendent of Documents, Government Printing Office. Besides being a fine professional job of publishing, the magazine reflects a most enlightened policy of telling the facts about fire accidents and highlighting the prevention methods.

It will be apparent to our readers that the editors of *Aircraft Accident and Maintenance Review* did not look on the following stories essentially as *fire* stories — you will note that they all concern aircraft maintenance oversights or failures, and the text is drafted purposely to attract the attention of U. S. Air Force mechanics who are the magazine's most important readers. It was especially interesting to note that in Air Force maintenance, fire prevention depends on the development and execution of proper aircraft maintenance procedures. The NFPA Sectional Committee on Aircraft Maintenance and Storage is attacking this problem by drafting good practice recommendations for each hazardous aircraft maintenance chore. Examples are NFPA Nos. 410A and 410B on aircraft electrical system and oxygen system maintenance procedures, NFPA No. 405 on safeguarding aircraft fuel tank atmospheres during ground handling operations, and NFPA No. 410C–T on aircraft fuel tank repair operations.

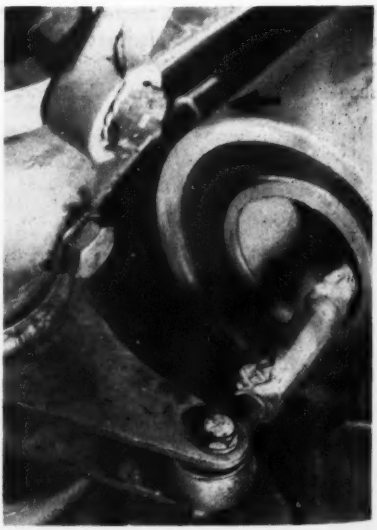
The following stories and photographs are reproduced from the September 1959 issue of *Aircraft Accident and Maintenance Review* with the permission of the editors.

A Misplaced Socket Wrench

This 100-ton Stratojet left the runway during take off at a speed of 70 knots, with the forward main gear locked at a 60° angle. The gear buckled, rupturing fuel lines and a forward fuel cell, resulting in total destruction by fire.

One of the crew members evacuated safely, but the copilot was fatally burned, the instructor navigator and student navigator received injuries and burns, and five firemen were hospitalized.

It is possible that this type of accident can be caused by inadvertent steering of the forward gear or by malfunction of the metering valve, but, *in this instance, an 11/32 inch socket wrench was found in the area where the nose gear collapsed.* Maintenance had been performed in the forward wheelwell prior to this flight. Investigations have indicated that, in at least two other instances, hand tools



This is the socket wrench which was responsible for the accident photographed on the previous page. Reporting such tragedies helps to educate mechanics on the importance of extreme caution in their aircraft maintenance procedures.

were discovered in a position to wedge between the differential arm and centering spring housing in such a manner as to displace the metering valve from centered position.

The fatality may not have occurred, had the aircraft commander been able to remove the canopy. However, the copilot was rendered unable, by shock, fire, and fumes, to assist with its removal. Inspection of remaining parts revealed excessive wear on forward rollers, hooks, and saddles. *It should be noted here that removal of this canopy after release is difficult, if not impossible, for one man . . . even if in perfect operating condition.* Ensuing examination of in-service B-47 aircraft revealed those same canopy parts, in many cases, were dirty and unlubricated.

Maintenance and flight crews are now being briefed to inspect the forward wheelwell, with particular attention on steering mechanism to insure that no foreign objects are present, and Handbooks have been supplemented to direct specific inspection in and around the steering differential area for foreign objects. Also, Interim Safety of Flight Supplements were published to provide additional instructions for emergency ground release of B-47 sliding canopy. Even so, it is possible that this costly and fatal accident could have been prevented, had proper precautionary measures been taken in compliance with directives already in existence.

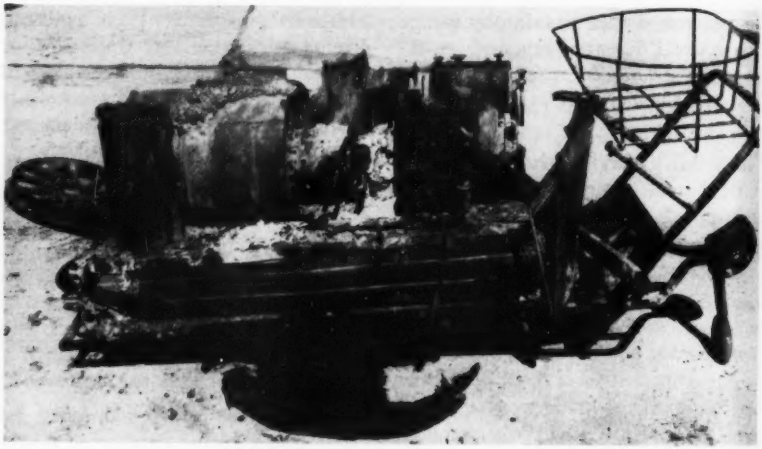
Weakened Drag Chute Lines

Recently a B-52 was lost on landing. "Malfunction of the drag chute" was all the communication said. Not a why or a wherefore about what failed or perhaps who failed. Just the words "malfunction of the drag chute."

Investigation revealed that the parachute failed during an aborted take off, and this is the time it should have functioned because it was engineered for an emergency. The parachute must be at its ultimate strength to withstand the greater load demand during an emergency. It has built into it a 2.3 safety factor. During routine landings the drag chute is used merely to save brakes and tires. It may at times be used on an abbreviated runway as an added precaution. But it is an emergency piece of equipment.

The cause of failure can be traced back to the maintenance personnel who be-

An emergency piece of equipment, the drag chute, had been allowed to become worthless because of cumulative unrepaired damages during use on routine landings. When it failed it resulted in this B-52 fire!



The use of this internal combustion portable heater to attempt "purging"* of the fuel tank of a KC-135 resulted in a $6,000,000 fire (see also photos next page).

came lulled into a false sense of security by the many safe deployments during routine landings. Right here is the problem: *the cumulative unrepaired damage to the drag chute has stealthily robbed it of its safety factor*, and while the parachute has worked for twenty landings, on the twenty-first — an emergency — it failed only because it had become an anemic weakling. Therefore, intelligent diagnoses of damage and repair are fundamental before every repacking.

$6,000,000 Coffee Break

A fuel boost pump in an inboard wing fuel cell required an O-ring seal replacement. To perform this repair, the wing fuel cell of the KC-135 had to be defueled and "purged"* of the flammable and toxic vapors. A technician, dressed in the authorized protective clothing, and with the proper, nonsparking tools, was to enter the fuel cell and perform the needed repairs.

With the $6,000,000 jet tanker aircraft positioned in the massive steel and corrugated metal nose hangar, preparations were made for the "purging" operation. The hangar doors were open sufficiently to afford adequate ventilation within the enclosure for normal expected conditions. Although Air Force Manual 32-3 (Ground Safety)† prohibits the use of combustion-type blowers for fuel tank "purging," a BT 400 combustion heater-blower unit was used.

The high capacity heater unit was placed outside of the hangar on a level approximately 18 inches below the floor level of the hangar. The heater unit was started and a sufficient length of flexible air duct was connected to heater and aircraft. The "purging" of the fuel cell proceeded uneventfully for about two hours when the operator shut down to take a refreshment break. Prior to shutdown, the air duct was disconnected from the aircraft and placed on the floor beneath the wing and fuel cell opening. The other end of the air duct was left connected to the heater unit.

*The use of the term "purge" in this article is not consistent with the use of the term in NFPA No. 405.

†Also prohibited in NFPA No. 405 "Safeguarding Aircraft Fuel Tank Atmosphere (Ground Handling)."

A nose hangar as well as the KC-135 was destroyed in this fire because the improper machine was used to air ventilate a wing fuel cell prior to repair of a fuel boost pump.

Upon his return to the "purging" operation approximately ten minutes later, the heater unit was started. A terrific explosion occurred. Witnesses stated that during the initial explosion, flames or "balls of fire" came out of the door openings at about the two-foot level. Immediately afterward the entire hangar was engulfed in flame. The aircraft, hangar, and heater unit burned to the ground.

Apparently the heavy fuel vapors settled on the hangar floor and fed into the length of air duct which led to the combustion blower unit.

With the highly volatile gases present in the unit, the first spark of the starting cycle apparently touched off the explosion.

The lesson to be learned again is that combustion heaters and combustible gases do not mix. At least three times previously, this same type of explosion has occurred, using the same type of equipment and under almost identical circumstances. A further point in the lesson to be learned is that we must provide the maintenance man with the proper tools and equipment, proper instructions, proper supervision, and proper support, if we expect him to do a proper job. If we don't, we are a party to the fact.

Manual fire control following an explosive fire origin is a particularly difficult chore. At least three other USAF similar fire losses are in their records with the same equipment responsible. Telling the stories of such incidents to flight line maintenance crews is powerful education.

Fire cause: not enough air in the tire! Not the actual ignition source but the real reason.

For Lack of Tire Pressure Check

The left main tire blew out just as the F–100D was lifting off the runway. The pilot decided to abort the takeoff, and in the process the nose gear collapsed and the left wheel separated from the aircraft. Sparks from the nose section sliding on the runway ignited the fuel spilling from the left fuselage area. The pilot evacuated safely, although the combination of the impact and resultant fire destroyed the aircraft.

The primary cause of the accident was listed as materiel failure. However, the investigation turned up some irregular maintenance practices that seemingly "just grew" without anyone realizing it.

Aircraft tire pressures were not regularly checked and different types of gages were used with no program of periodic calibration. Several maintenance men stated that, many times, if the pilots were in a hurry to take off, the aircraft would be signed off — even if the preflight had not been finished and the tires not checked.

The organization overhauled its maintenance directives and SOPs and set up a program calling for close supervision of preflight inspections. A good preflight inspection of the tires might have detected the conditions that caused this tire failure.

This is the fire damaged F–100D which burned after the pilot aborted his take off following a tire blow out. Runway friction heat probably ignited the magnesium wheel casting and this spread to fuel vapors released by impact damage to the fuselage fuel tanks.

Improper Bolt and Nut Only Finger-Tight

The proper torquing, even though the wrong type bolt and nut were installed, could have prevented this accident.

But the maintenance technician used the wrong bolt and nut assembly and only turned the nut finger-tight. In flight the nut backed off, the bolt fell free and the pilot lost control of the stabilator. The RF–101C dived into the runway, just after becoming air-borne, fatally injuring the pilot.

The accident cause was revealed when a panel on the left side of the vertical fin was removed. The stabilator control rod assembly had separated from the antipitch-up lever assembly and was wedged against the stabilator pusher cylinder assembly.

An analysis indicated that the drilled-type bolt and castellated nut had not been used. There were two approved substitute bolts with self-locking nuts that could have been used but were not. Investigators found an undrilled bolt, of similar length but of slightly smaller diameter and concluded that it had been used in place of the authorized bolt.

In studying the condition of the push-rod and antifriction bearing it was determined that the nut had backed off the bolt, apparently after take off, allowing the bolt to fall free. Later tests showed that this unauthorized bolt and nut would have remained in place had the nut been properly torqued.

The aircraft records showed that the stabilator actuator had been recently removed and a new one installed. Also uncovered was a sequence of events that seemed designed to set up a safety-of-flight hazard. The technician was apparently sent on a job for which he was not sufficiently qualified. He failed to finish the work that might have corrected a faulty installation.

Another fatal crash fire caused by a maintenance oversight which resulted in a safety-of-flight hazard. Just an improper bolt not properly tightened.

Fire damage to a USAF aircraft because electrical power was applied prematurely during maintenance.

Use of a tag system such as this is also recommended in NFPA No. 410A when repairing aircraft electrical systems.

Tag to Warn

Want to save your bird to fly another day? Next time you pull that fuel boost pump or remove a heater or similar component that will surely cause a small fire or explosion if someone flips the electrical power on the aircraft, try attaching red streamers to the battery switch and to the external power receptacle. Printed on the red streamers should be the message, "AIRCRAFT UNSAFE FOR ELECTRICAL POWER."

No sweat, you say? A flight chief, two electricians and a flight engineer had a difficult time explaining how they set fire to four expensive aircraft, causing varying degrees of damage. Give it a try — keep that bird in shape to fly.

Streamers can be made of waterproof material and details for use and storage should be published in a local SOP.

This is another method of protecting your interests on the flight line!

An explosion on the flight line started this fire during a fuel boost pump repair operation. Again, premature energizing of the aircraft electrical circuit was responsible.

The Ryton Automobile Factory Fire

By H. S. C. Tanner

Chief Fire Officer, County Fire Brigade, Warwickshire County, England

At 6:30 P.M. on Tuesday, September 22, 1959, a blue flame was seen racing along the steel trusses of a large unsprinklered automobile manufacturing plant located in Ryton-on-Dunsmore, near Coventry, Warwickshire County, England, and known as the Ryton Works of the Messrs. Rootes, Humber Ltd. Four hours later the fire was under control. Even though it had been skillfully confined to one quarter of the 10.5-acre plant, the damage estimates have run to $8,500,000.

The Factory

An aircraft assembly plant was built by the British Government in Ryton-on-Dunsmore in the early part of World War II. The buildings have been taken over since by Messrs. Rootes, Humber Ltd. for the manufacture of the Rootes line of automobiles. There are two major buildings on the 67-acre premises. The larger (where the fire occurred) is an unsprinklered, mostly undivided, 590 ft. by 775 ft. high, 1-story, steel-framed assembly building, also used for office space, receiving and incoming parts storage. The "smaller" building is an unsprinklered, 6.3-acre, 1-story shipping building separated from the larger by 60 feet and used for "final inspection, rectification* and packing." The 60-foot separation between these two buildings was partially covered by roofs over the alleyway below.

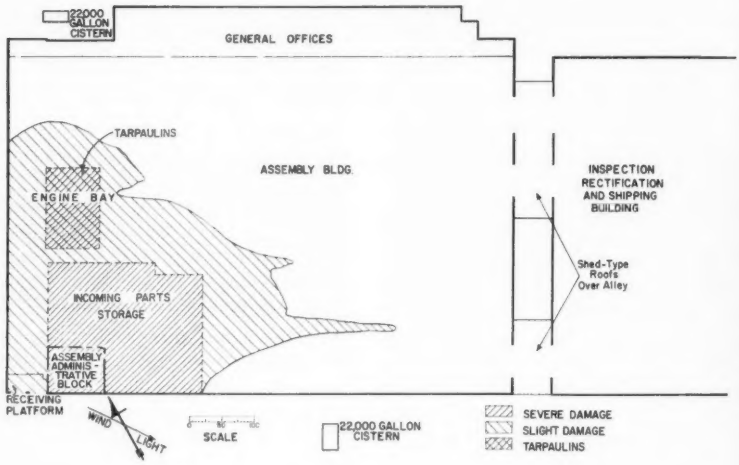
*Ed. Note: Americans may not be familiar with "rectification." This step in production is a readjustment of errors made on the assembly line and discovered by the inspection.

In one corner of the assembly building (see diagram) there was a receiving platform and about one-eighth of the building nearest this platform was used for storage of the received parts. Tucked in this storage area and under the high roof of the assembly building was a 70 ft. by 80 ft., 2-story brick enclosed section used for storage on the first floor and for the administrative office of the assembly line on the second floor. Ordinary glass windows in the office section permitted observation of the assembly area. Other offices and some showrooms were located on the opposite side of the assembly building.

The steel framing for the building was enclosed by nonload-bearing brick panel walls. Unprotected steel columns and trusses supported the saw-tooth-shaped asphalt-protected corrugated metal-covered roof. One side of each "saw tooth" was covered with wired glass lights.

The Fire

Painters, hired under contract from an outside firm, were working under the roof of the main assembly building. They were applying a flammable liquid-based aluminum paint to the asphalt surface on the underside of the roof and roof trusses over the assembly area. In order to protect men and cars underneath from the dust being removed and from the paint being applied, it was necessary for the painters to form a temporary ceiling under the trusses. This was done by suspending tarpaulins by ropes from the trusses. None of the



approximately 10,000 square feet of tarpaulins thus used was flameproofed.

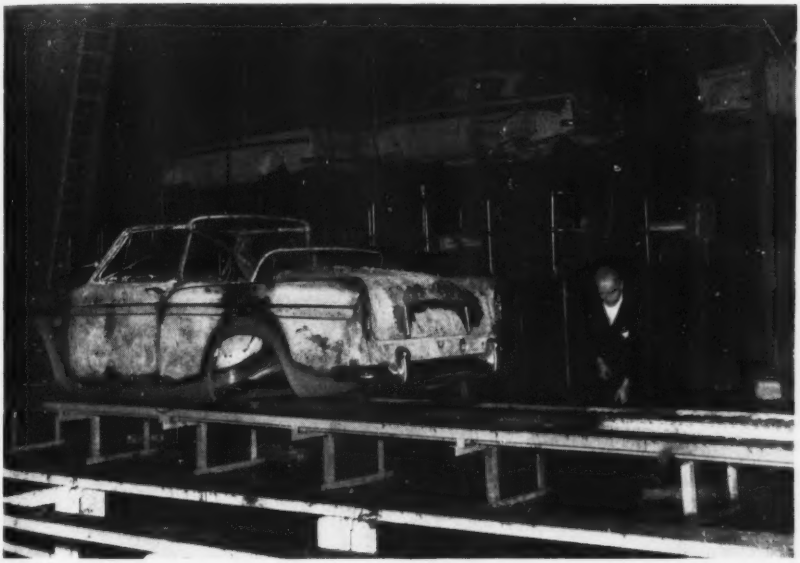
The dust on the underside of the roof and on the roof trusses had been analyzed before the fire. This analysis had revealed that the dust (which included paint and wax deposits) was at least 75 per cent combustible.

Shortly before 6:30 P.M. one of five painters was climbing down a ladder to report that the area presently being painted above the "engine bay" was almost completed. He heard a shout of "Fire" from above and looked up. About 40 feet from the immediate painting area he saw what appeared to be a blue flame racing along a roof truss above the tarpaulins and toward the parts storage area. This man then ran to a manual pull station for the plant fire alarm system (6:30 P.M.).

Another witness of the start of the fire was looking through the receiving doors about 300 feet from the painting operation. He saw a "spear of flame — blue pointed" but due to its distance from him thought it was a welder at work, until the flames quickly began to reach up toward the roof. As he ran toward the area he saw the burning center of a tarpaulin fall to the floor. He stated that immediately the flames shot from the floor to the ceiling and began spreading rapidly across the freshly painted asphalt coating of the saw-toothed roof. As the tarpaulins ignited, burned, and fell, flames at floor level began to spread quickly among the stored combustibles.

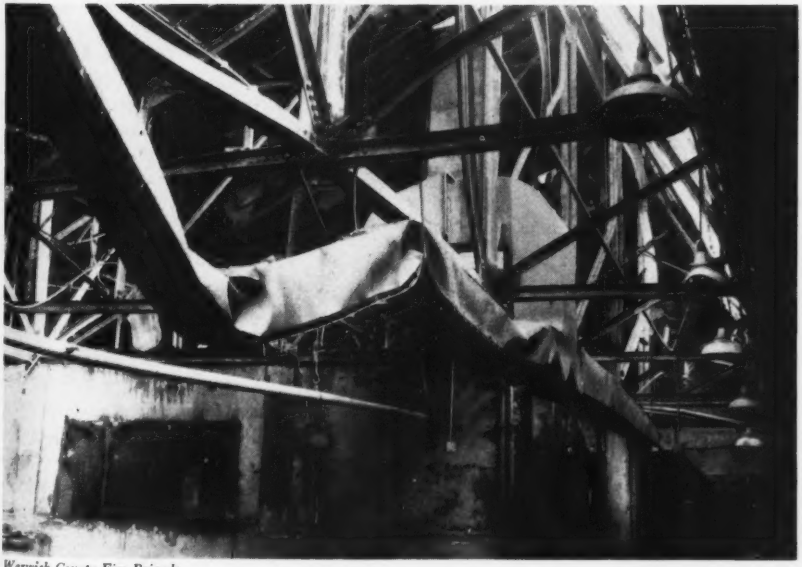
As soon as the alarm rang in the plant fire brigade headquarters located about 1,100 feet from the fire area, the two on-duty paid firemen responded with a pumper. At the same time the plant workers on the fire brigade began to assemble. On entering the building (about 6:32 P.M.), the two brigade firemen found the fire burning over a large area of the roof and floor. Asphalt from the burning roof and lead alloy from melted cable coverings and window flashings were already falling.

One of the paid fire brigade members experienced difficulty in finding a telephone that had not been already interrupted by the fire. A delay of five minutes from the time of the arrival of the plant fire brigade and the receipt of the call by the outside fire fighting forces



Warwick County Fire Brigade

An interior view of the damage in the assembly area. Note that the falling asphalt and tarpaulins were able to ignite the interiors of the convertibles more easily than the sedans.



Warwick County Fire Brigade

View of the damage on the second floor interior of the enclosed assembly administration section of the assembly building. Deformed structural members indicate the severity of the heat. Note in the upper left of the picture the light steel frames which were used to support combustible fiberboard insulation.

resulted. While this fire fighter was searching for a telephone, the other was helping to organize the arriving members of the fire brigade, and the contractor's men were using extinguishers to fight the fire. The part-time members of the fire brigade and other factory employees, as they arrived, laid a hydrant line into the fire area.

Despite the fire-fighting efforts now in progress, the fire spread into the second floor of the assembly administration offices, either by means of the asphalt-coated roof or through plain glass windows overlooking the factory floor which were broken by the heat. Once inside this brick-walled section, the flames reached a combustible fiberboard ceiling, lining the roof in this area. This material created intense heat and additional smoke as it quickly burned.

The assembly building was heavily charged with smoke soon after the fire was discovered. This condition continued until the wooden supports for two large roof exhaust fans burned away allowing the fans to drop to the floor. The openings thus created in the otherwise unvented roof over the fire area helped to relieve somewhat the heavy smoke conditions.

Fifty minutes after initial discovery the final call for assistance "Make pumps 25 and turntable ladders 3"* was made. A relay from the Avon River 2,700 feet distant was established and by 8:15 P.M. was supplying 800 gpm through three hose lines to the two 22,000-gallon underground cisterns used as pump water supply. With hoses supplied from the cisterns, fire fighters wearing breathing masks were able to enter the building and contain the fire in one corner of the building.

*Ed. Note: In England the fire officer decides how much equipment the situation calls for and the dispatcher sees that he gets it. Thus the call for 25 pumps is a total and not a request for 25 *additional* pumps.

Warwick County Fire Brigade
Damage to a masonry wall at the head of the east staircase in the assembly administration section of the assembly building.

The Damage

The worst damage to the factory building was located within the brick enclosed administration offices. Here the heat of the fire warped the exposed structural steel roof members and cracked the masonry walls. Severe structural damage also occurred throughout the parts storage section. The area around these sections, totaling about one-quarter of the 10.5-acre building, was slightly damaged by heat, smoke and water. Effective action by the fire-fighting forces is credited with this limited extent of the loss.

The Cause

As several electrical circuits ran through the area of origin one of the possible causes of fire was an electrical short circuit which ignited either the dust, the painters' tarpaulins, or the paint vapors. Another suspected source of ignition of one or more of these fuels was high pressure steam. The steam in the pipes in the area of fire origin was at a temperature between 315°F and 340°F. Smoking was discounted as none of the painters had cigarettes aloft with them.

The Fatal Köyliön Prison Fire in Finland

Flames swept through a 1-story wooden prison barracks in Köyliön, Finland, so rapidly that the guards were driven from the building and 16 of the prisoners died, still locked in their cells. The early morning fire on July 1, 1959, emphasizes again the similarity of the life safety problem the world over.*

The Prison

The prison was made up of many buildings spread over a wide area. The guards' homes, the agricultural buildings, and the central telephone switchboard were all located outside the prison compound. The prison compound consisted of four 1-story wooden buildings surrounded by a high wire fence. These slightly detached buildings were arranged in the form of a rectangle. Two were long 800-sq.-meter (8600 sq. ft.) barracks buildings housing the inmates. The other two buildings, forming the ends of the rectangle, contained the administrative offices and the storage, heating, and bath facilities.

The fire originated in and was confined to one of the two barracks buildings. The interior arrangement of this long building consisted of a central corridor running its length on either side of which was a row of cells. A fire wall with a fire door at the corridor opening divided the building into two sections. The steep-roofed barracks buildings were constructed of wood framing covered with building paper and rough unmatched 1-inch boards. The walls were insulated with a stuffing of hay and wood chips. The rough-wood interior walls of the building, in the cells and in the corridors, had been covered by a painted cardboard. In some places the lower parts of the walls were covered by a series of thin wooden strips. Thin wooden strips were also used as a ceiling finish. The floor was covered with boards. Both the floor and the ceiling were insulated with straw, sawdust, hay, and wood chips.

The cells were equipped with "normal"-sized windows protected by firmly attached iron bars. The cell doors were made of hard fiberboard panels set in a wooden frame and separated by an air space. There were no openings in the cell doors. The locks on all cells were small, with small keyholes and small keys. Each cell had a different key and each guard carried on a ring the keys to all cells.

Fire Preparedness

Water for fire fighting was supplied by an underground water system with a pressure of approximately 50 psi. The water mains supplied an outside hydrant near the administration building and standpipe and hose systems in each building. Each barrack had two hose stations, one at each end of the main corridor, and was equipped with four water-filled portable fire extinguishers. There was also a portable fire pump with nozzles and hoses located in the

On July 3, 1959, the fire inspector for Finland's Turku and Pori provinces, Fire Commander Ilmari Juvakoski, made an investigation and report of this fire. This QUARTERLY report is based on Fire Commander Juvakoski's report as printed in the September issue of *Palontorjunta* (the Finnish Fire Protection Journal).

* See the pictures accompanying this article for two other 1959 prison fires. The 1959 toll for the "errors" in the design and the operation of these three prisons was 45 persons killed.

prison compound. In addition to the water mains there was an underground cistern in the middle of the prison yard with "plenty of water."

The prison fire brigade was well organized. The guard commander had attended fire-fighting school. Two prisoner fire-fighting teams of eight men each had been formed. In addition all guards were trained in fire fighting three times a year.

The prison alarm system consisted of a telephone network on which five personnel at a time could be called at their homes by the operator at the prison switchboard. Response to the telephoned alarm usually took a few minutes as the personnel lived a distance away from the compound. Only two telephones were located within the prison compound. These phones were in offices in the administration building which were locked at night. The guards carried keys to the offices.

The night guard force consisted of four men on duty in the prison compound. Two were on patrol and two on "resting turn." Of the 150 prisoners in the prison on the night of July 1, 1959, 90 were housed in the barracks which would soon be involved.

The Fire

In the summer, the windows at the ends of the corridors in the barracks were opened to improve ventilation. To improve further both ventilation and convenience "the fire door had recently been left open regularly, wedged open with a piece of wood at floor level."

It was very early in the morning when, in a cell in one of the barracks, a prisoner, suspected of having a mental difficulty and about to be moved to a mental hospital for observation, ignited the mattress in his cell. The fire quickly involved the cardboard wall covering and entered the wall through the cracks in the dried boards. For a reason not explained in the report (perhaps noise of the fire or cries of the prisoner), the guards on patrol were attracted to the cell. When they opened the door, they were greeted by an unexpected burst of flame. The guards leaped back from the onrush of flame, now intensified by additional air from the corridor. They were then unable to get close enough to shut the cell door. The cardboard and the thin wooden strips on the wall and ceilings in the corridor ignited quickly. One guard headed down the corridor to give the alarm. He knew this was most important. He paused to try to close the fire door in the corridor but found it stuck. Unable to close it easily he thought that the other guard would do this and therefore did not hesitate further.

He paused again before leaving the building to awaken the two guards on "resting turn." Then he ran out of the barracks, past the telephones locked in the offices and out of the compound to the switchboard and gave the alarm verbally to the switchboard operator. The operator immediately started alerting the prison personnel by telephone, and then began to call the outside fire departments. As the guard returned he saw flames pushing out of the window in the involved cell and out of the windows at each end of the corridor.

In the meanwhile the other guard on duty at the discovery had tried to open the nearest cell door. He tried one key, the smoke was getting thick, it didn't work — he tried another, the heat was pressing down from the ceiling, it didn't work either. Reluctantly he had to flee from the building. He had to leave in the opposite direction from the still wedged-open fire door. He did not hesitate but headed for the other barracks where he laboriously found keys to open each individual cell to let out

Wide World

The Ocean County Jail fire at Tom's River, N. J., on August 23, 1959, occurred when a mentally defective prisoner set fire to the foam rubber of his padded cell in this inadequately staffed jail. When the guards arrived, the smoke and heat had already blocked access to the central unlocking device for the cells. Eight prisoners were killed in this fire-resistive building before they could be freed or before the fire was brought under control. The fire was reported on page 6 of the November 1959 issue of the *NFPA Fire News*.

Wide World

This night fire in an unsprinklered combustible dormitory of the state-run boys' industrial school in Wrightsville, Arkansas, on March 5, 1959, occurred when a vent pipe from a wood stove ignited the combustible fiberboard ceiling. As no substitute had been provided for the sick, key-carrying building caretaker and no release mechanism had been installed for the "escape-proof" window screens, 21 of the 68 interned boys were trapped while the others miraculously managed to break down the screens and escape. The fire is reported on page 10 of the April 1959 issue of the *NFPA Fire News* and as the frontispiece of the April 1959 QUARTERLY.

the prisoners so they could help in the rescue efforts.

The two guards on "resting turn," on being awakened, headed to the yard and began to set up the fire equipment for operation. The arriving prisoners and guards manned the hose lines and rescue equipment. There were only enough hose lines for the yard side of the barracks building. On this side of the burning structure it was possible to use rescue equipment under the cover of the hose lines, and most of the men were rescued from these cells. On the other side, however, the prisoners could be released only from the cells not already involved; by the time the outside fire departments had arrived, further rescue efforts were hopeless.

The Lessons

The Building Exits Code (NFPA No. 101) has a special section on recommendations for life safety in penal institutions which should be studied by all responsible authorities. Among other things set forth in this code are recommendations for a reliable means of prompt release of inmates in case of fire and complete automatic sprinkler protection in buildings constructed in whole or in part of combustible materials.

Basically, as Fire Commander Juvakoski's report states, "It is apparent that we should use persons familiar with the structural fire protection (and life safety) requirements in the design and construction of buildings."

Danish Excursion Boat Disaster

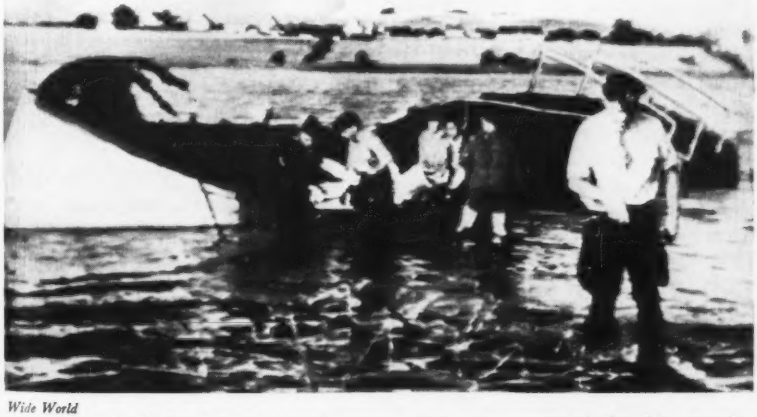
Haderslev Park Lake in southern Jutland, Denmark, was the scene of an excursion boat fire on July 8, 1959, that took the lives of 55 passengers. Many of the 39 survivors were hospitalized with severe burns.

The 45-foot-long wooden gasoline-powered motor boat made regular runs between Haderslev and a small summer restaurant at the other end of the lake. Up until four years ago the boat had been approved for 75 passengers but approval had been reduced to 35 because the owner refused to procure more than 35 new life belts. On the fatal run 94 people were aboard consisting mostly of elderly women and children.

At 5:30 P.M., July 8, while the boat was making a half-hour return trip to Haderslev, the motor stopped. On discovering that the fuel tank was empty, the boat owner (one of the two-man crew) broke out a gallon can of gasoline, cut the metal fuel line between the carburetor and fuel tank, and connected the gasoline can to the fuel line by means of a flexible rubber tube. Since the outside diameter of the metal fuel line was 6 mm (¼ inch) and the inside diameter of the rubber tube was 10 mm (⅜ inch) gasoline escaped at the connection and spilled on the hot motor.

Ignition did not occur until the vapors had spread throughout the canvas-canopied area where the passengers sat. As flames flashed through the vessel igniting the canopy and clothing, panic gripped the overcrowded vessel. The boat owner tried to make his way to the bow where the life belts were stored but was forced back by the passengers. He then tried to maneuver the burning boat toward the shore about 300 feet away but most of the passengers had jumped overboard or been burned to death by the time the boat had grounded. Of the 55 killed, 39 drowned.

This report is based on information furnished by NFPA member H. Cortsen-Møller, Copenhagen, Denmark. Mr. Cortsen-Møller is chief engineer of Danks Brandvaerns-Komite (The Danish Fire Prevention Committee).



Wide World

Careless handling of gasoline and overcrowding were responsible for this excursion boat disaster costing 55 lives.

Organizing Plant Fire Protection

By J. Ward Bush

Chief of Plant Protection, Caterpillar Tractor Company

The key word in the title of this paper is "Organizing." This single word is the most important factor in the entire field of fire prevention and control. It transcends mere planning and paper procedures and requires ACTION. It is only by *doing* that we accomplish our goals.

No industry is too small to organize for fire protection. As an illustration, consider a plant I know that consists of a two-car garage. Here, the owner, with the help of his wife and son, runs a plastic lamination business. The shop is clean and orderly. Scrap is disposed of in closed metal containers. Flammable liquids are properly stored and handled. Ample portable fire equipment is available. A new exit door was made at the rear of the building. Ample aisle space was provided to reach either door. I asked who planned the layout. The owner said he and his wife had built the operation a little at a time. He had invited the local fire chief in, and the chief had recommended what extinguishers to get and suggested the exit door at the rear. A local fire equipment vendor delivered the extinguishers and demonstrated their use. I considered the fire protection organization for this plant commensurate with that provided at our plant, which includes over a hundred and fifty acres under roof.

The ACTION of Organizing

Organizing plant fire protection requires six steps:

Accept management responsibility

Consider the fire potential

Take steps to provide physical protection

Instruct employees in fire prevention and control

Offer full cooperation to the local fire department

Never accept an "It Can't Happen Here" attitude

Any industry, which has fulfilled these requirements, has effectively organized for plant fire protection.

Acceptance of Management Responsibility

It is the responsibility of any plant management to plan and provide a program designed to insure the safety of employees, company property, and continuity of operation. This responsibility is fixed with the plant manager. The size of the plant, the nature of the product, and the scope of the operation will usually determine whether he will directly assume this responsibility, assign it to a subordinate along with other duties, or hire a specialist as a fire safety manager. In either case, the basic approach remains the same — consideration must be given to:

1. The layout of the plant and the construction of the buildings.

2. The nature of the product and the hazard involved in its production.

3. The relative location of the plant to other properties from which fire might be communicated.

4. The number of employees and if this number includes a percentage of female or handicapped persons.

Based on a paper presented at the NFPA Fall Conference held in Des Moines, Iowa, November 10–12, 1959.

The service of industrial fire brigades goes way beyond their role in active fire protection work.

5. What protection can be expected from the local fire department.

6. The amount of risk which the company is willing to assume.

No program, whether it be for fire safety or product improvement, will be a success unless it has the full support of top management. Lip service to local fire ordinances or insurance company requirements will not assure a safe plant.

Management will find their insurance carrier's engineering department a valuable source of reference and advice, but the carrier should not be expected to plan and implement the program.

Another valuable source of information is from your membership in the National Fire Protection Association. Of special value is the NFPA's pamphlet No. 6–M, "A Guide for the Organization of Fire Safety in Modern Industrial Organizations."

Consider the Fire Potential of Your Plant

Some large plants, with especially hazardous operations, are equipped with private fire protection organizations which are adequate to handle their fire potential up to conflagration proportions.

By far the largest percentage of industries are organized to combat small fires and to control the more serious ones pending arrival of outside protection. The loss potential study and planning at the Caterpillar Tractor Co. may be of interest. It is not presented as the only or best answer but it is a method which has been tried by the fire of experience and found to be adequate for our needs.

Fire prevention planning at this company starts on the drawing boards of the Planning and Engineering Departments. By the establishment of a close liaison between the Plant Protection and these departments, the company is assured of:

1. Fire resistant construction throughout for new work and the replacement of existing combustible installations with fire resistant material as changes are required.

2. Provision of adequate exits to insure safe evacuation under emergency conditions.

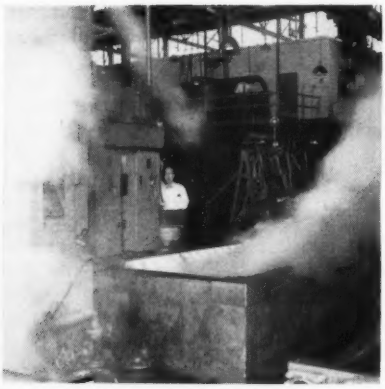
3. Provision of automatic fire doors, water curtains, etc., to restrict the spread of fire.

4. Automatic alarm systems to provide notification to personnel of the presence of an emergency.

5. Provision of automatic sprinklers, carbon dioxide, and dry chemical systems for the protection of special hazards.

6. Adequate protective water supply to assure acceptable volumes at workable pressures for a reasonable length of time.

Each hazardous condition and situation is analyzed to see if it can be corrected or is a calculated risk of operation. If it is a calculated risk, it is then necessary to minimize the hazard in every way possible and provide protective equipment for fire control. Again the best results can be obtained only through close cooperation with the Research, Planning, and Engineering Departments. We have established a Hazardous Materials Control Commit-



Photos on this page show progressively a test of a process protection system.

tee. This Committee consists of representatives from the Research, Engineering, and Purchasing Departments, Metallurgical Laboratory, Medical Hygiene, Safety, and Plant Protection Divisions. Whenever any hazardous materials are

Low pressure carbon dioxide nozzles are strategically located over the hazard area.

brought into the plant, they are studied by this committee. They determine where and how the material is to be used, and if it offers a fire or health hazard under the specified terms of use, it is then the committee's responsibility to decide the necessary precautions to be observed or to present recommendations to management that the material be barred from use at the plant. Management has seen fit to stand behind these recommendations, resulting in safer operations.

A high concentration of the heavy gas to smother the theoretical fire is assured at high discharge rates.

Take Steps to Provide Physical Protection

After your study has been made and the fire potential of your plant determined, immediate steps should be taken to assure that protection is provided. Information regarding this phase can be

Now the gas has settled down on the heat-treat quench tank and on the surrounding floor area.

obtained from your insurance carrier, the inspection bureau, your local fire department, and the standards of the National Fire Protection Association.

Instruct Employees in Fire Prevention and Control

The effects of excellent planning and the provision of adequate physical protection can be completely nullified if untrained or improperly trained employees fail to follow safe practices. In very small plants it may be possible for every employee to be given special training in every phase of the plant's operation, to make every employee aware of the existing hazards, and to train him to handle emergency equipment. As the size of the organization increases, it becomes necessary to select certain individuals and give them special training. Frequently, these men are selected from among the operating personnel and serve as volunteers to supplement a comparatively small full-time force.

The Fire Safety Manager may present this training personally or an instructor may handle the job. In either event, the instruction should be given by a qualified person with the ability to pass along the information he possesses. Originality in the construction of gadgets, demonstrations and other visual aids is an important asset. The instructor must be progressive and willing to accept new methods and equipment, if they are found to be more adaptable than those now in use. He must be sold on the program presented as his attitude will be accepted and reflected by the men. A good well-rounded program can fall flat if not properly presented.

Industrial Volunteer Firemen

Volunteer firemen perform an amazing service to industry. Their contribution

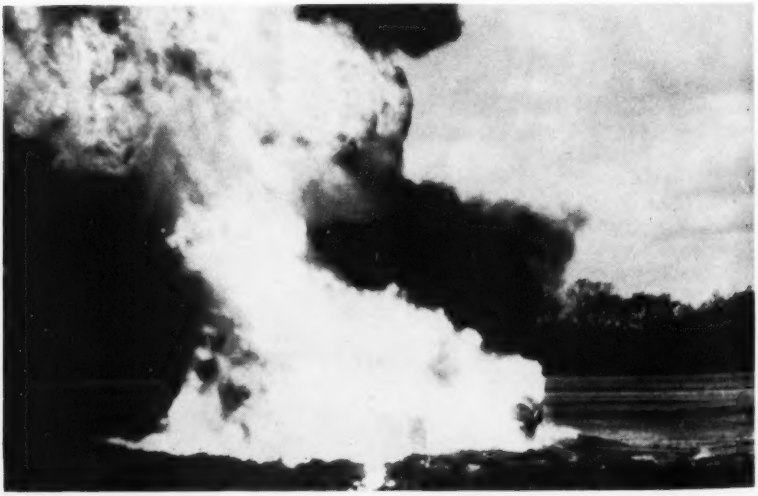
The instructor is telling plant guards and volunteer firemen why the company is removing all their vaporizing liquid extinguishers on a five-year plan and replacing them with CO_2 and dry chemical units.

A gas-fed fire to give employees training in handling such elevated pipeline fires.

is intangible and cannot be measured in dollars and cents, but in addition to their efforts toward the protection of the plant, they do an outstanding job of spreading the gospel of fire prevention and the building of a fire conscious attitude among their fellow employees.

Of prime importance in the selection of an industrial volunteer fireman is an interest in the work. Seldom does an applicant who joins your department only for the money involved or who has been arbitrarily assigned to it by his supervisor turn out to be a credit to the department. The volunteer department at the Caterpillar Tractor Co. has a roster of 150 volunteers in addition to the paid men with over 50 per cent of them active in the 23 fire departments and fire districts in the five counties surrounding the plant.

After it has been determined that a man has an interest in the work, his foreman or supervisor is contacted to see if his normal duties are such that they can be interrupted if his services are needed as a fireman. Continuous process operators, tool and die sinkers, pattern makers, and other highly skilled personnel are not usually selected, as their work includes considerable overtime which would interfere with their



A typical flammable liquid pit fire used by the Caterpillar Tractor Co. in training the industrial fire brigade (see also photo next page).

Brigade members learn the techniques of using water spray to extinguish fires of this type at their training grounds (see photo previous page).

attendance at drills and training classes. Maintenance men and construction personnel are excellent candidates as they are usually well acquainted with the plant and familiar with water mains, electrical service, gas lines, etc. Also, their work keeps them in practice climbing and handling ladders, ropes, and an assortment of fire service hand tools.

The third step in the selection of a fireman is an examination of his personnel record or history folder. It must be realized that his assignment may carry him into restricted or critical areas. It will pay you to be sure of his background. Then submit the application to the Medical Department for approval. You will be amazed at the number of applicants who will be rejected. It is almost impossible for you to determine if he has a bad heart, a hernia, a previous back injury, or something of that nature. A check of his physical condition in advance may save you a lot of embarrassment later on.

Training Periods

From the experience at the Caterpillar Tractor Co. it has been found that better results are obtained when training periods are held *outside* regular working hours. It is also true that only with day shift workers can you effectively use the period after their shift ends for instruction. Usually the day shift man is reluctant to get up early enough to allow sufficient time to drill before he goes to work. However, second and third shift employees held after their regular work shift are sleepy and less apt to be attentive or cooperative.

Visual Aids

It is a well-established fact that a person retains a far greater percentage of the information he receives by sight than through any of the other senses. Perhaps the most extensively used visual aids are the moving picture projector and the slide projector. To these have been added several types of reflex projectors which project on the screen any picture, sketch, or map, placed on the view table. There are many sources of training films available at little or no cost. Among these are the National Fire Protection Association, National Safety Council, fire insurance companies, fire equipment manufacturers, and state college libraries. Many fire equipment companies also have cutaway models, or pictures of cutaways of their equipment, which offer valuable assistance in understanding the unseen operating features. Many lessons can be learned through pictures cut from publications for use with reflex projectors. A complete set of ladder evolution pictures

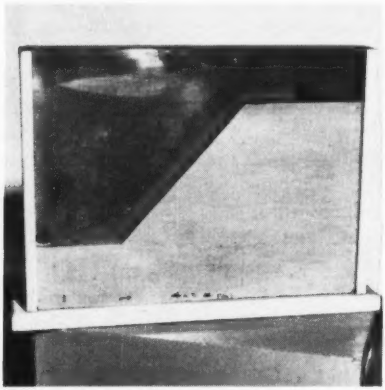
Demonstration equipment is useful for training. This is a dust explosion chamber.

mounted on heavy cardboard has been found to be a valuable aid in teaching new men proper ladder techniques.

The Training Method

The Training Section at the Caterpillar Tractor Company has developed many demonstration units such as a model building for ventilation training, a model factory complete with protective water supply, and an explosion chamber for demonstrating the hazards of handling flammable liquids and gases. The standard job-instructor training method which employs the following five steps is used: (1)Tell or demonstrate how it is done. (2) Help the man do it. (3) Put him on his own. (4) Correct his errors. (5) Give him practice. The training course includes instructions in the chemistry of fire, recognition of fire hazards, handling of first-aid equipment, operation of fixed fire protection systems, operation of major equipment, and fire control operations. These fire control operations are further subdivided as follows: safety to life and rescue operations, protecting exposures, forceable entry, ventilation, extinguishing evolutions, and salvage operations. At the end of this course of instruction, if a man cannot efficiently perform the work, it is usually safe to assume that he does not have the necessary interest and he should be replaced.

An explosion chamber for showing the hazards of flammable liquids.



Heavier-than-air gases are ignited in this demonstration unit at the base of the incline.

Cooperation with Local Fire Department

The industry which does not cooperate with the local fire department is setting up a severe impediment to its own protection. If you buy a fire extinguisher and do not know how to use it or do not read the instructions until a fire occurs, even a small fire may get beyond your control. The extinguisher

A model factory used to demonstrate use of carbon dioxide flooding. Caterpillar uses this type protection for some of their industrial process hazards, and the model aids in explaining its operation to employees.

is no less effective but you lost your advantage when you lost valuable time. Similarly, the efforts of an efficient fire department are often hampered and valuable time is lost because prior planning was not done.

Invite your local chief to visit your plant and bring, at least, his chief officers with him. Arrange with him how alarms will be handled; be sure his truck will not be delayed at the gate by a plant officer who has not been notified of the fire. Whether you like it or not, the local fire chief is in charge of your fire-fighting operation. Advance planning on how you can capitalize on the know-how of both the chief and yourself will avoid embarrassment and delay at the time of an emergency.

Many fire departments offer training programs where industry can send employees for fire training or will send a fireman into a plant to instruct volunteers.

Don't Be Complacent

An attitude of complacency is an invitation to trouble. It has been said that in industry today nothing is so permanent as change. Protection that is adequate today may not suffice tomorrow. If we are to keep our plants safe, we must be constantly alert to occupancy or process changes through a comprehensive system of inspections. Through attendance at fire schools and conferences and through constant study of new developments in fire protection techniques, we can keep informed. The information is available to representatives of large and small industry alike, and the success of your Organizing for Fire Safety will depend on the ACTION you take.

What Causes Electrical Fires?

Note: The following information is based on a compilation of reports of 39,392 electrical fires during the years 1954 through 1958 submitted by electrical inspectors from 237 cities in the United States and Canada to the International Association of Electrical Inspectors. The tabulation and regrouping of the material in the form presented in this article was done by the staff of the NFPA in order to present the information in a concise form. The annual statistics for the years noted have been published in various issues of the IAEI News Bulletin published by the International Association of Electrical Inspectors, 612 North Michigan Avenue, Chicago 11, Illinois.

A total of 39,392 electrical fires were reported during the years 1954 through 1958 to the International Association of Electrical Inspectors (IAEI) from 237 cities in the United States and Canada.

Table No. 1 lists the major fire causes in five categories. It will be noted that the leading cause was equipment that wore out in service (28 per cent of all electrical fires). Improper use of approved equipment was the second most frequent known cause (14 per cent), while "accidental occurrence" and defective installation were responsible for 12 and 11 per cent respectively of all the electrical fires reported.

Table No. 2 reports the tabulated origins of these electrical fires and gives, as far as possible, the specific types of electrical equipment involved. It will be observed that electrical appliances were the source of more than half of all the fires within this category and that motors were responsible for 30 per cent of these 20,544 fires. Heated appliances, television receiving sets, neon signs, and radio receiving sets follow as the other principal sources of appliance fires.

Wires, cords and cables combined were the origin of approximately 27 per cent of all the fires reported. Wires and cords, by all odds, were the source of the greatest difficulty.

Terminal equipment, which includes fixtures, outlets, switches, lamps, receptacles, and sockets, was the third major grouping of equipment identified as being the most prevalent source of electrical fires; combined, they accounted for 12 per cent. Within this grouping, fixtures, especially electric discharge lamps (fluorescent type fixtures) were responsible for almost half the total of 4,773 fires originating in terminal equipment.

The other sources of electrical difficulty are listed in the Table and include transformers, lightning damage to electrical equipment, panel and control boards and meters.

In using these figures, it should be noted that no data are available on the number of devices in service so that it is impossible to assess the relative hazard of the various items listed as opposed to each other. All that can be said about the tabulated data is that it gives some guidance as to the sources of difficulty in electrical services and equipment.

The reports received by the IAEI from the 237 cooperating cities were voluntary services by the electrical inspectors following a report form developed by the IAEI. Greater participation among the 533 cities having a population in excess of 25,000 and among similar

Canadian municipalities is urged in the IAEI's Bulletin and the Bulletin also notes that there are conspicuous omissions in the number of reported incidents and too many of the fires are listed as "unknown" or "not reported."

It is only through detailed study of every fire reported that intelligent measures can be taken to combat the menace of electrical misuse which today results in millions of dollars in fire damage, untold hardship and loss of life. Such studies point to situations that can be improved by more attention to maintenance, they show up Code violations, and point to changes that may be made in the National Electrical Code (NFPA No. 70) which, when enforced, will correct fire hazard conditions. The IAEI will be glad to send to electrical inspectors, fire marshals, government bureaus, and insurance inspectors, instructions on the standard reporting methods used by that organization in collating the data on which this article is based.

Table No. 1

Tabulation of the Causes of Electrical Fires — 1954-1958

Based on Statistics Published by the International Association of Electrical Inspectors

Cause of Fires	No. of Reported Fires	Approx. Per Cent of Total
1. Worn out in service	10,994	28
2. Improper use of approved equipment	5,525	14
3. Accidental occurrence	4,661	12
4. Defective Installation	4,465	11
5. Unknown or not reported	13,747	35
Total Fires Reported	39,392	100.0

NOTES TO TABLE NO. 1

The five standard classifications noted above are used to secure comparative results from all reporting agencies. The IAEI "Manual for Investigating and Reporting Electrical Fires" gives the following explanations for the five items:

1. "Worn out in service" indicates equipment actually worn out in service or wires having served a full and useful purpose for a period of years which have deteriorated strictly from service thereby resulting in a fire.

2. "Improper use of approved equipment" indicates that while the equipment itself complies with safety standards of recognized testing laboratories, fires have occurred because such equipment is used under conditions not covered by its approval — i.e., use of No. 16 lamp cord for extension lights in hazardous locations.

3. "Accidental occurrence" implies fires caused by such occurrences as clothes left in contact with lamps, dropping materials into electrical equipment accidentally, heated appliances left on unintentionally, etc.

4. "Defective installations" means installations which are improperly installed in a manner not acceptable by the National Electrical Code — i.e., a fractional horsepower motor automatically started which does not have overcurrent running protection as recommended by the Code.

5. "Unknown or not reported" should include only those fires of probable electrical origin wherein the evidence has been destroyed to such an extent that a cause cannot be assigned.

Table No. 2

Tabulation of the Origins of Electrical Fires 1954-1958

Based on Statistics Published by the International Association of Electrical Inspectors

Note: This tabulation does not indicate the relative safety of the various wiring methods or appliances since no data is available on the number of installations of each type in service.

Equipment of Origin	Totals		Cause of Electrical Failure				
	Number of Fires	Approx. Per Cent of Total	Worn Out in Service	Improper Use of Approved Equipment	Accidental Occurrence	Defective Installation	Unknown or Not Reported
Appliances	**20,544**	**52**	**6,416**	**2,861**	**2,199**	**1,711**	**7,357**
Motors (Winding Burnouts and Sparks)	**12,004**	**30**	**4,276**	**1,224**	**695**	**1,123**	**4,686**
Domestic Refrigeration	3,971		1,343	195	272	249	1,912
Fractional HP, Automatic Control	3,028		1,543	377	200	432	476
1 HP or Over, Automatic Control	636		290	74	55	107	110
All Manual Control	1,219		582	213	80	218	126
On Elevators	165		55	6	17	9	78
Sparks from Motor Brushes	116		39	10	36	12	19
Others (Details Not Reported)	2,869		424	349	35	96	1,965
Heated Appliances	**4,359**	**11**	**740**	**1,283**	**896**	**232**	**1,208**
Irons (other than in Residences) and Other Heated Tools and Appliances	3,772		658	1,112	681	207	1,114
Irons in Residential Occupancies	587		82	171	215	25	94
Television Receiving Sets	**2,600**	**6**	**945**	**212**	**309**	**148**	**986**
Neon Signs	**821**	**2**	**215**	**77**	**141**	**174**	**214**
Radio Receiving Sets	**623**	**2**	**235**	**36**	**68**	**33**	**251**
Electric Welders (Sparks from)	**124**	**—**	**0**	**27**	**85**	**1**	**11**
Toy Trains	**10**	**—**	**5**	**2**	**3**	**0**	**0**
Motion Picture Projectors	**3**	**—**	**0**	**0**	**2**	**0**	**1**
Wires, Cords, Cables	**10,534**	**27**	**2,195**	**1,631**	**1,038**	**1,994**	**3,676**
Wires	**5,743**	**15**	**968**	**348**	**726**	**919**	**2,782**
Cords	**3,689**	**9**	**923**	**1,144**	**187**	**787**	**648**
Cables	**959**	**2**	**276**	**124**	**102**	**259**	**198**
Christmas Tree Wiring	**143**	**—**	**28**	**15**	**23**	**29**	**48**
Terminal Equipment	**4,773**	**12**	**1,592**	**525**	**619**	**476**	**1,561**
Fixtures	**2,206**	**6**	**779**	**203**	**200**	**163**	**861**
Electric Discharge Lamps	1,748		501	168	145	113	821
Chain	195		122	14	19	9	31
Drop Cord	263		156	21	36	41	9
Outlets	**982**	**2**	**202**	**65**	**93**	**129**	**493**
For Fixtures and Junctions	457		175	55	79	98	50
For Other and Misc. Purposes	525		27	10	14	31	443
Switches	**538**	**1**	**280**	**38**	**46**	**81**	**93**
Lamps (Incandescent)	**456**	**1**	**90**	**108**	**179**	**26**	**53**
Receptacles	**400**	**1**	**144**	**85**	**69**	**50**	**52**
Sockets	**191**	**—**	**97**	**26**	**32**	**27**	**9**

Table No. 2 (Continued)

Equipment of Origin	Totals		Cause of Electrical Failure				
	Number of Fires	Approx. Per Cent of Total	Worn Out in Service	Improper Use of Approved Equipment	Accidental Occurrence	Defective Installation	Unknown or Not Reported
Transformers	1,228	3	447	137	159	127	358
Neon Sign (Portable)	119	—	51	6	7	15	40
Neon Sign (Not Portable)	223	—	96	16	33	60	18
Low Voltage	416	1	190	29	25	28	144
High Voltage (Other Than Neon)	349	1	109	86	69	22	63
Voltage Not Reported	121	—	1	0	25	2	93
Lightning Damage to Electrical Equipment	729	2	7	6	452	32	232
Panel Boards, Elevator Control Boards	442	1	81	130	61	56	114
Cutout Cabinets and Distribution Panels	379	1	70	112	52	55	90
Elevator Control Boards	63	—	11	18	9	1	24
Meters (Defective)	94	—	32	6	23	18	15
Miscellaneous Other Electrical Equip.	1,048	3	224	229	110	51	434
Total	39,392	100	10,994	5,525	4,661	4,465	13,747

Things to Consider When Buying . . .

Automatic Fire Detection for the Home

By Southworth Lancaster
Member, National Fire Protection Association

Next to preventing every possible fire in your home, the most important step you can take for life safety is some way to get warning if, in spite of everything, fire does break out. The ideal method is to install an automatic sprinkler system, such as you see in factories, hotels and public buildings. A sprinkler system has certain major advantages. It not only puts water on the fire immediately but also gives an automatic alarm without requiring an operator or attendant to set it in action. Sprinklers, however, have not been widely used in dwellings, largely because of lack of proper promotion. A second alternative is the installation of an automatic fire detection system properly installed and employing tested components. We will discuss only this latter approach in this article.

In considering automatic fire detection for life safety, it must be remembered that a fire may fill a home with smoke and poisonous gases almost as soon as most fire detection devices will operate. If there is a fire in your living room while you are asleep, and your only way out is through that room, you may have a minute or two in which to escape after the alarm sounds. In case the fire starts in a basement, behind a closed door, you will probably have some minutes more before dangerous smoke and gas can pass through the door or before the door will burn through. Thus a necessary step to be reasonably safe is to have some direct means of escape from your bedroom, and to familiarize yourself with its use by periodic drills, *before the fire occurs*. In other words, do not buy an automatic fire detection system in the mistaken belief that this is *all* you need to do to be safe from fire.

Obviously, such a fire detection system must be reliable. It must never fail at the crucial moment. Only equipment thoroughly checked by competent testing laboratories can assure you of dependable performance, and then, again, only if it is properly installed and maintained. Underwriters' Laboratories, Inc., (UL) and the Factory Mutual Laboratories (FM) are the two principal agencies in the United States which regularly carry on tests of fire detection equipment. The Underwriters' Laboratories of Canada (ULC) provides the same service in that country. Accordingly, you should make sure that each and every component of your system — the thermostatic device, the control unit, the wiring or tubing and the audible alarm device — carry the UL, ULC, or FM label which is the sign that it has been tested and found reliable.

Many purchasers of fire equipment for the home fail to realize the differences between fire equipment and practically everything else in the home. If the lights do not work, if the doorbell does not ring, if the heater fails to operate, the trouble is obvious and something will be done about it at once. Not so with fire equipment. It may not be called upon to operate for years, and,

you hope, will never be needed. You know from experience that any mechanical or electrical equipment in your home can fail. When most things fail, it is a matter of inconvenience, but not a matter of life or death. When you are relying on fire detection, failure may well mean death.

Warning

Unfortunately, there are many unlabeled devices on the market which may seem attractive at first glance to the layman. You will find them for sale at almost any hardware store, and even in drug stores and supermarkets. Many are advertised in "do-it-yourself" magazines and Sunday newspaper supplements. Some of these are operated by flashlight batteries which are supposed to give warning by sounding a buzzer or bell, like a doorbell or telephone bell. Others are small cans with a whistle on top. Still others are designed to be plugged in on home electrical circuits. In making your choice, look for a UL, ULC, or FM label. If a UL or ULC label is there, be sure that the heat detection device is installed so as not to exceed linear spacing (explained later) indicated by these Laboratories, or the safety you think you are providing will be incomplete.

Types of UL, ULC, or FM Tested Equipment

There are electrical, compressed gas and spring-wound fire detection devices available for home use that are UL, ULC, or FM tested. Also available, but more expensive, are pneumatic tube, flame and smoke detection devices and systems. These latter types are used principally in industrial and commercial applications, their cost being normally too high for installation in residences.

These tested devices may also be divided in two classes which we can call "system components" or "local, single station types." Electrical "system components" include detection elements, signaling system control units, and alarm devices. When these components are properly electrically interconnected and provided with a power supply, they are capable of automatically sounding an alarm when a certain temperature condition is reached. Compressed gas operated "system components" consist of detector elements interconnected by tubing to an alarm device which likewise functions when a certain temperature is reached. A "local single station" device combines in one unit the detection element, the power supply and the alarm. The UL currently lists three manufacturers of compressed gas operated and one spring-wound "local single station" devices.

The UL and ULC, as indicated previously, establish spacing limitations for both types of detectors. It is important to realize that where "local, single station types" are used, the alarm must be of sufficient intensity to alert all occupants in every part of the house while observing the spacing limitations on each device. For instance, if a "local, single station" device is placed in the basement of a home, it must be capable of arousing sleeping occupants on the upper floors and additional such "local, single station" devices must be spaced throughout the home to assure proper coverage and each must be audible throughout the house.

Types of Electrical Detection Systems

The heart of any electrical automatic fire detection system is a device which will sense a fire or unusual heat. This is called a thermostat. For our present purposes, we can define a thermostat as a device that is actuated by heat and makes or breaks an electrical contact to give a warning when interconnected electrically to an alarm device. Thermostats may be "unit" (spot location)

devices interconnected with electric wiring or "line" (continuous) type, every inch of which is sensitive to heat. Each electrical system has a "Signaling System Control Unit" in which are relays, switches, lamps, wire terminals, and so on. When the system is powered by the home electric circuit, this control unit transforms the house current to energize the detection circuits, the detection devices, and the alarm signal (bell, siren, horn, or equivalent) that gives the actual warning. Naturally, these components and the wiring, as well as the detection unit, should have the UL, ULC or FM label to ensure that they are properly designed. As for the wiring to interconnect unit devices, flexible cords are not satisfactory; UL-labeled insulated solid (not stranded) conductors should be used.

Gas-Operated Detectors

Detectors employing a compressed gas as the energy source for the alarm mechanism are usually operated by a fusible element. The heat softens the solder in the element and the pressure of the gas in the cylinder ejects the solder, thus sounding an alarm. These may be "local, single station units" or detectors interconnected with tubing as indicated previously.

Spring-Wound Detectors

These detectors operate when heat causes the fusible element in the device to soften, allowing a spring-motor to go into operation and sound the alarm. They are listed solely as "local single station units." Multiples (i.e. additional units) would be required to secure the desired coverage of the dwelling.

Power Sources for Electrical Systems

An electrical detection system is no better than its power supply. Generally speaking, the ordinary home electric service is an adequate primary supply, so long as it is transformed and rectified to supply a potential of not more than 30 volts and not less than 6 volts of direct current to the fire detection system. The detection system power supply should be taken from the building service entrance side and not on the same fused circuit as other house wiring. However, there is always the chance that the main power supply will be interrupted, perhaps by storms or because outside repair work is going on. Accordingly, there must be a secondary or "standby" power source which could consist of nickel-cadmium batteries, the standard rechargeable (wet) or non-rechargeable (dry) batteries. If the main power supply does fail, the system should automatically switch to its secondary power supply and set off a trouble signal. The trouble signal should be audible and should be a different sound than that given for an actual fire. It can be provided with a switch to shut it off, once the power interruption has been recognized. However, the device should also have a light which will remain "on" as long as the primary power circuit is out of service; this light will "cut out" automatically when the power supply is reinstated and the audible trouble signal will sound again until the trouble signal silencing switch is returned to its normal position. In principle, this is not unlike the cut-off device used in house heaters which have an electrical thermostatic control.

It has to be admitted that the standby batteries can present problems. The homeowner must remember to replace nonrechargeable batteries at least once a year and to keep the rechargeable ones in top operating condition. This is no different from the responsibility the homeowner must assume for his automobile or other mechanical devices in his home—(his furnace, his refrigerator, or what not). The housing or recepta-

cle which holds dry cell batteries must be plainly marked to show when the next replacement is due. Fire records show instances where detection systems, which were otherwise properly installed, failed in an emergency simply because their batteries had given out!

Power for Compressed Gas Detectors

In systems operated by compressed gas, the gas containers provide the source of power. The containers of UL listed devices conform to the regulations of the Interstate Commerce Commission for compressed gases. This fact is only important as far as the safety and reliability of the containers are concerned. Most current models have a gauge or indicator to show when a loss of the compressed gas (usually Freon) occurs. Other types bear a label or set of directions for determining the proper weight of the unit. When any gas is lost, the unit must be replaced. Tubing, of specified maximum length, may be used to connect two or more detecting elements as noted previously. The integrity of the tubing is vitally important. To assure this, the tubing must be installed by the manufacturer's trained representative in accordance with the conditions of the Underwriters' Laboratories' recommendations which accompany the equipment, and the homeowner must see to it that the tubing is maintained intact and in sound condition.

The Alarm Device — All Types

The adequacy of the alarm-sounding device is most important. Ordinary doorbells or buzzers will not do. The sound must be so distinctive that it cannot be mistaken for anything else and positive enough to demand instant attention as soon as it is heard. Large bells, horns, sirens, and similar noisemakers have been devised and are available. Whatever signal is selected should be of a type listed by the UL, ULC or FM for fire alarm service. The signal must create a sound volume sufficient to attract attention and maintain it for at least five minutes. The importance of a loud signal cannot be too often stressed; it must be capable of arousing all occupants from their sleep, even behind closed doors!

In the ordinary home, the best place to put the alarm device of a system is in a common corridor to the bedrooms or in the master bedroom. Large houses may require more than one alarm device, their location being governed by the design of the house and the way the spaces available are utilized. Sometimes it may be a good idea to install a signal on an exterior wall, so that the alarm will alert neighbors or persons in the vicinity.

For the "local, single station" units, the alarm device is an integral part of the detector. As noted earlier, the sound must be loud and strong enough to alert everyone in the home regardless of the distance factors involved.

Testing the Equipment

The circuits of municipal fire alarm systems are usually tested at least twice a day. While you may not need to test your home system quite so often, you will nevertheless want some means of making sure that your own fire alarm is in working order. For electrical systems, the best way is to put in an auxiliary switch or push button, so arranged that you can make a "hundred per cent circuit test" and assure yourself that your entire system is intact. This may or may not require a separate test circuit depending on the design of the system. In any event, the test should permit a check of the power supply, the circuits to the detection elements, and the alarm signal. Note, however, that as a rule the detection devices them-

selves cannot be tested without destroying them or damaging their sensitivity. This is one reason why such stress is laid on UL, ULC, or FM labeled devices which are of known reliability.

The integrity of compressed gas operated systems (other than "local, single station" devices) can be tested by using a special test gas cylinder installed for this purpose. The "local, single station" devices cannot be tested without damaging the detection component, as noted above. Again, this emphasizes the importance of UL listed units and the need to check periodically by the visual gauge or by weighing that the units are in operating condition.

If you are the average householder, you may now be tempted to stop reading, with the thought that it is all too complicated for you. Don't stop. It is all really quite simple, much simpler than your TV set when you come to think of it and much simpler than assembling a Hi-Fi set.

Complete Systems Not Listed

At this point it has to be explained that the Laboratories do not list *complete* home fire detection systems as such. The reason is that no single complete system can be offered to fill all needs. Each must be "tailor-made" in accordance with the needs of the home it is to protect. Since two houses are seldom identical, no two systems can be arranged exactly alike. The components of a system are tested and listed, and only such listed components should be used.

Installation

Some of the large firms marketing UL, ULC, or FM listed equipment are in a position to install professionally their devices. Others, supplying electrically operated equipment, employ local electricians or contractors. It pays, as always, to select carefully the company with whom you do business. Door-to-door promotions of even UL listed devices have been made by individuals and organizations lacking knowledge of the installation techniques specified by the Laboratories. Be wary and be wise. Establish the reputation of the seller of this equipment as you would your plumber, your furnace repair man, your doctor. It might pay to check him with your Better Business Bureau or your local Fire Department. You may be personally "handy" and, if willing to take the responsibility, able to install the equipment yourself. If you do so, be sure to follow the manufacturer's instructions and the hints given in this article. At any rate, where any connection is made to your house current a qualified electrician should be hired. Do not attempt to touch the house wiring yourself unless you happen to be a full-fledged electrician!

The best plan is to engage a reputable firm which understands the fire alarm business and let them do the work. Usually the firm will submit a proposal for the installation in advance and if one is not submitted, you will do well to ask for it. If you have any doubts about the proposed layout or the firm's ability to install it, it is a good idea to check it with your local electrical inspection authority or fire chief before you go ahead.

When a device designed for this service is tested and listed by the UL or ULC, the listing always includes specifications for the *linear* distance between detection devices. In other words, there are definite rules to show how far apart the detection devices may be placed and still be able to operate within the required time limits, that is, quickly enough to be effective as a warning. It is dangerous to ignore this listing or attempt to protect only those areas which you think have obvious fire

hazard potentials. If you are going to install protection, install it throughout the house because the effectiveness of the system depends entirely on the proper placement of the detection devices. Each enclosed space requires protection.

Typical Installations

Suppose you have selected an electric system with unit-type thermostats. You should then have one unit in each room, and more than one if the maximum permitted linear spacing between the units is exceeded because of the dimensions of the room, or to put it differently, if the room is big enough to require two or more units placed at the prescribed intervals. On the other hand, if your choice falls on a thermostatic device of the continuous or line type, a section of this continuous-type detector should run through every room, of course observing the permissible distances between lines. Remember that archways or covered beams extending more than 12 inches below the ceiling make each such space a separate room, even if there is no door. In unsheathed basements where ceilings consist of open joists the linear spacing between unit detectors or lines should be reduced by 50 per cent.

Where "local, single station" units or interconnected gas operated detectors are used, the UL listing will give you similar spacing requirements. Do not "short change" the equipment by installing too few units to do the job because actually you are only "short changing" yourself. Know positively that the strength of any alarm device of the "local, single station" type will be adequate to alert you no matter where you might be in the house.

The majority of the tested and listed fire detection devices are designed to be mounted on the ceiling fully exposed to the currents of air moving over the ceiling surface. From the viewpoint of appearance, this position has certain advantages and at the same time increases the efficiency of the devices, assuming they are properly spaced, by making use of the physical law that heat rises. Occasionally, it may be desirable to mount the detectors on the wall rather than on the ceiling. This can be done safely with *some* devices provided they were so tested and listed by the Laboratories and are installed in strict conformance with their limiting specifications which require placement close to the ceiling.

The test button or switch is best located in a spot which will be passed by some responsible person on the way to the sleeping quarters. This is a hedge against forgetfulness. If the test button is in a place where it surely will be seen, the risk of overlooking it is very small. The system should be tested often enough to make sure that it is in working order. A once-a-week test is not too often, and this can well be done some night before the family retires. It is the night fire that is the most dangerous.

After Installation

When a system installation is completed, you as purchaser should demand that the installer make in your presence an acceptance test. This should include proof that the alarm signal can be heard even when all doors between the signal device and the rest of the house are closed. Remember that the alarm must arouse you from sleep or catch your attention over the clamor of radios or TV sets, other house noises, or street sounds. You should satisfy yourself that the system can do exactly this. Otherwise, your money and effort have been thrown away. The same judgment should be applied, as previously explained, to each of the multiple units of "local, single station" devices, al-

though the only way to conduct such tests is to use a demonstration device of the same size and sound capacity as the device actually in service.

Some installers offer a combined guarantee and maintenance contract on a term basis including annual inspection and maintenance. Such contracts are usually good and are evidence of the interest and reliability of the installer. This takes part of the responsibility from your shoulders, for now you need only make sure that the system stays in running order. Even if you do not have a maintenance contract, you will want to be acquainted with a reliable serviceman whom you can call on to repair a breakdown, just as you call your plumber or your heating engineer if you have trouble in those departments. You may be specially capable and able to look out for your detection system yourself—in that case, remember that you are taking on a job for 365 days in the year (one more for leap year)!

A defective detection and alarm system is worse than no system at all, for it produces a false sense of security which is the sure road to disaster.

Summary

You may go year after year without a fire emergency, and yet the fire you do not expect may break out at some unpredictable moment of any time of day or night. So many things can cause a fire, more so today than ten years ago because so many new things with dangerous possibilities have entered our daily life. When the unexpected happens, when the unpredictable moment comes, and it may come despite all your fancied precautions, the detection and alarm system that brings you to your feet with its instant warning can save your property, your home, your life.

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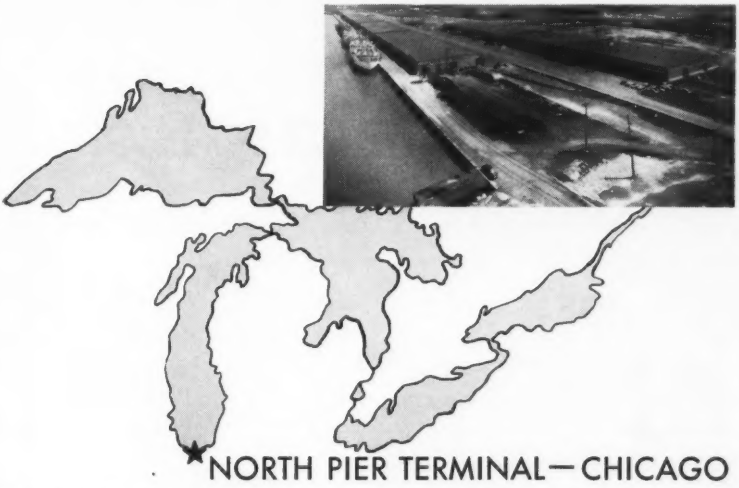

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one of the most modern and strategically located freight centers in the world is

ADT PROTECTED

This terminal is a shipper's dream, with more than a quarter of a million square feet in ship-side storage. President W. W. Huggett employs ADT fire and burglary protection services, here and in their several other locations, and says that it presently

saves $23,000 a year

Adequate protection depends not only upon the quality and installation of the alarm devices but also upon the constant inspection and maintenance provided year after year. The real economy—and loss immunity offered by ADT—are two good reasons why it protects industrial, commercial and institutional properties valued at more than 56 billion dollars.

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A NATIONWIDE ORGANIZATION
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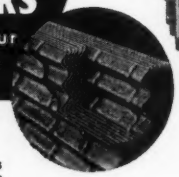
LOW COST
FIRE & EXPLOSION PROTECTION

for FLAMMABLE LIQUID STORAGE

WITH "Varec"
FLAME ARRESTERS
in combination with your
VENT VALVES



Flame Arrester Unit
listed by
UNDERWRITERS' LABORATORIES
Approved by Associated Factory Mutuals
Laboratories and other governing agencies.

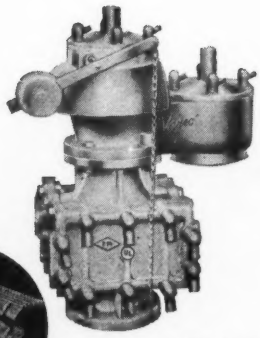


Fig. No. 5800A
Conservation Vent Unit consisting of VAREC Vent VALVE in combination with VAREC FLAME ARRESTER

You can rely on VAREC CONSERVATION VENT UNITS to provide full fire protection on your liquid storage at low cost. Protection against entry of flame through the venting device is certain when Varec Flame Arresters are used. Protection against excessive pressure or vacuum is assured by the VAREC VENT VALVE. The combination unit gives you complete security against major hazards of flammable liquid storage. Average installation costs 1/10th of 1% of your investment in tank and products. Secure full details from your VAREC Representative or write factory.

NF-3

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THE VAPOR RECOVERY SYSTEMS COMPANY

COMPTON, CALIFORNIA, U. S. A.

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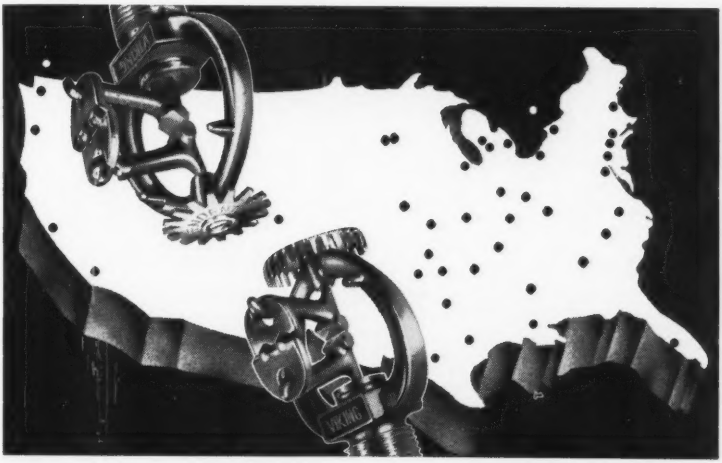

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For fire control whatever it happens to be, call the nearest Viking Representative

ATLANTA — Crawford & Slaten Co. **BOSTON** — Viking Automatic Sprinkler Co. **BUFFALO** — Viking Automatic Sprinklers, Inc. **CHICAGO, MILWAUKEE** — Viking Automatic Sprinkler Co. **CINCINNATI, CLEVELAND, INDIANAPOLIS, LOUISVILLE** — Viking Sprinkler Co. **DALLAS, HOUSTON, JACKSON (Miss.), MEMPHIS, NEW ORLEANS, SAN ANTONIO, FT. SMITH** — Texas Automatic Sprinkler Corp. **DETROIT** — Viking Sprinkler Co. **GRAND RAPIDS** — Viking Sprinkler Co. of Western Mich. **HIGH POINT, N. C.** — Viking Sprinkler Co. **HUNTINGTON, W. VA.** — C. W. Hutchinson, Inc. **DECATUR (Ill.), DENVER, KANSAS CITY (Kan.), OMAHA, SAINT LOUIS, WICHITA** — Walton Viking Co. **LOS ANGELES, SAN FRANCISCO, PHOENIX** — California Viking Sprinkler Co. **HILLSIDE (N. J.), NEW YORK, MANCHESTER (Conn.)** — Viking Sprinkler Co. **PHILADELPHIA, WASHINGTON (D. C.)** — Viking Sprinkler Co. **PORTLAND (Ore.), SEATTLE, VANCOUVER (B. C.)** — Viking Automatic Sprinkler Co. **ST. PAUL, MINNEAPOLIS** — Hudson Viking Sprinkler Co. **TAMPA** — Florida Fire Sprinklers, Inc. **TORONTO (Ont.)** — Viking Automatic Sprinklers, (Canada) Ltd. **HASTINGS, (Mich.)** — The Viking Corporation.

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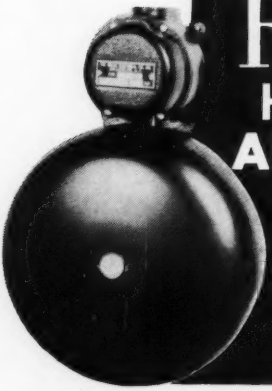

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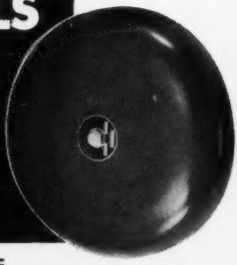
HEAVY DUTY ALARM BELLS
GONGS and BUZZERS
Weatherproof Watertight



Weatherproof —
Sizes 3", 4", 6", 8", 10", 12"
DC—6—220 V. · AC—12—220 V.
Watertight —
Sizes 3", 4", 6", 8", 10", 12"
DC—6—220 Volt · AC—12—220 Volt
60 Cycles, 110—220 Volt, 25 Cycles

3 TYPES OF
UNDERDOME BELLS
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Sizes 6", 8", 10". Cast aluminum housing
Hot Pressed Steel Gong Shell
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Voltages are the same as Neck Type

Special Windings on request.

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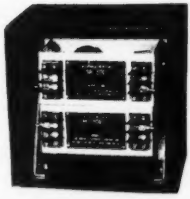
Write for Catalog Material and Prices!

AUTOMATIC BATTERY CHARGER, High and Low Current

The unit is designed for use on any storage batteries not subject to heavy drains. It will trickle charge the battery indefinitely because of its automatically decreasing rate of charge.

For use with six cells (12 volts). Automatically controlled by saturable reactor. Continuous output one ampere. 22.5 watts, 118 volts, 60 cycles. 3% Regulation. 9" x 9" x 6" — 14 B & S gauge steel wall cabinet. 15¼ lbs. U.L. Approved. **No moving parts.**



MODEL BC-12

Manufacturers of a complete line of
CENTRAL OFFICE and LOCAL FIRE ALARM DEVICES
- **automatic alarm devices • sprinkler alarm and supervisory devices**
- **burglar alarm devices and accessories. DYNALARM (sound detection for both reverberant and non-reverberant vaults).**

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Maximum Security . . .

This 250,000-gallon Horton Waterspheroid is on 24-hour fire watch at Automatic Electric Company's multi-million dollar plant near Chicago — ready to supply water *instantly* to 14,500 sprinkler heads. Then, too, it stores water for the general daily needs of the huge facility.

Waterspheroids — available in standard capacities ranging from 250,000 to 500,000 gallons — combine dependable service and modern design with the *plus* advantage of skyline advertising. Horton Waterspheres provide the same benefits in the 25,000 to 250,000-gallon capacity range. Write today for the brochure *The Watersphere and Waterspheroid.*

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Manufacturers of all kinds of approved devices used in Central Station Systems or Class 'A' or Class 'B' Proprietary Fire Alarm Systems, either automatic or manual.

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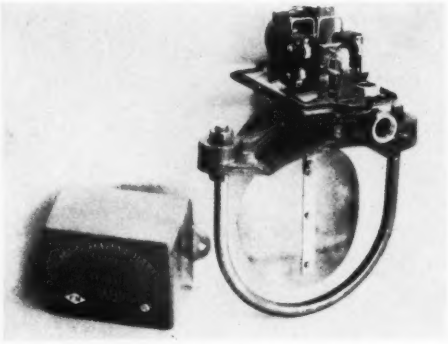


Model PRS-1

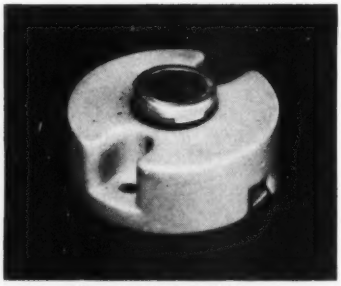
Sprinkler Waterflow Alarm

This device is approved by Factory Mutual Laboratories and Underwriters' Laboratories, Inc.

- This device is also made as Model PRT-1, a coded waterflow transmitter.

5-inch size shown above. To install simply drill 2-inch hole in pipe.

- Also made in explosion proof models.
- Made in all sizes from 2½" to 8".
- Has instantly recycling pneumatic retarding device, preventing false alarms.
- Has enclosed electrical contacts for any voltage not exceeding 15 amp. 125 volts, A.C. and ½ amp. 125 volts, D.C. Operates on all water pressures or surges.



Size is 1⅝" x ⅝"

Tempo-Set Model A Fire Detector

Underwriters' Laboratories, Inc. Approved.

- Self restoring and can be heat tested.
- Electrical contacts are silver or gold and are enclosed.
- Very reasonable price.

- Tempo-set Model A is approved in either open or closed circuit and the temperature ratings are 135 and 200 degrees.
- Approved maximum distance between thermostats on smooth ceilings: 20 feet.
- Electric ratings are 125 volts 1 ampere, A.C. or 24 volts 0.5 ampere D.C. or less.

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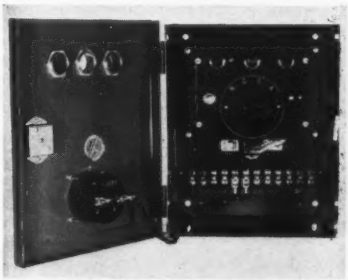
Proprietary & Remote Panels For Fire Headquarters

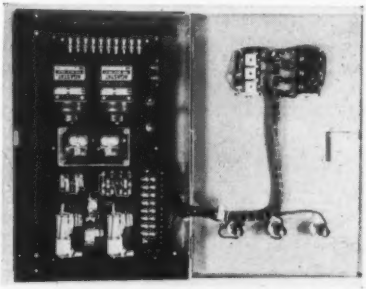
This Fire Headquarters Unit is designed to be used primarily for the receipt of signals at a remote station when actuated by a local alarm unit in the protected premises. It is electrically supervised and will give a trouble signal in case of open and ground and will also receive an alarm under these conditions. This panel is made for 12 or 24 volt D.C. operation.



Local Non-Coded Fire Headquarters Unit

Automatic McCulloh Class A Proprietary Panel

This single circuit panel is mounted in a red metal cabinet 18 x 12 x 6 inches, with switches and lights. This panel operates on the well known McCulloh principle. Signals are ordinarily received over a closed supervised circuit. With the McCulloh principle, a signal will be received over the circuit even though a single break or a single ground, or both, has occurred on the signaling circuit. This panel automatically adjusts the circuit for these fault conditions instead of the customary switches which are adjusted manually. A break or ground will be immediately indicated by a light and audible signal. The relays used in this panel are very sensitive and will receive signals from a considerable distance on No. 26 gauge wire and longer distances from heavier gauge wire. This panel operates on 24 or 48 volts of D.C. and requires a battery and rectifier for its operation.



Model ACP Single Circuit

Manual fire alarm boxes, automatic sprinkler alarm transmitters, automatic fire alarm, watchman supervisory signals, etc. can be received and recorded on this panel.

BOTH OF THE ABOVE PANELS ARE "APPROVED" BY UNDERWRITERS' LABORATORIES, INC.

Nation Wide
Central Station Protection Services

Sprinkler Valve Alarm — Complete Sprinkler Supervisory — Manual Fire Alarm — Automatic Fire Alarm — Temperature Alarm — Oil Burner Supervision — Burglar Alarm — Hold-Up Alarm — Vault & Safe Protection

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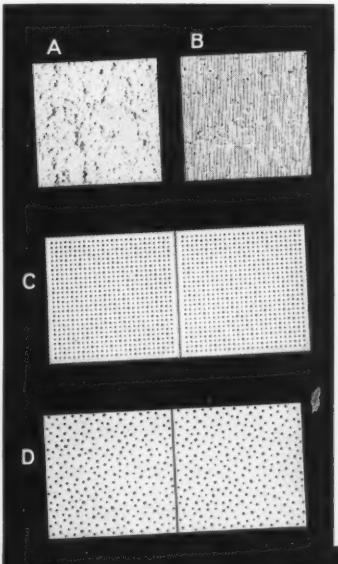
...and they're ALL "by CELOTEX"!



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G.—SUPRACOUSTIC*
Glass Fiber Panels

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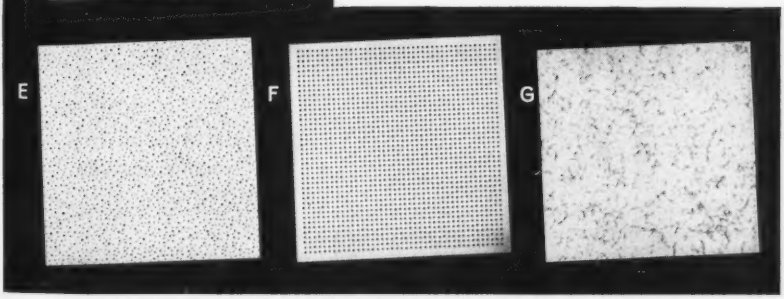

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Sound Conditioning

Products to Meet Every Building Code

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Check These Features of Kinnear "Akbar" Rolling Fire Doors

- Automatic release in case of fire.
- Positive, spring-activated start.
- Operable after automatic closure.
- Easily raised and reset after periodic testing.
- Curtain can't travel beyond fully closed position.
- Also operable for regular daily service.
- Labeled by Underwriters' Laboratories, Inc.

Whether you are considering new fire doors—*or checking existing ones*—make sure they have the features listed at right!

This combination of advantages is available only on modern AKBAR Rolling Fire Doors, made exclusively by Kinnear.

In today's AKBAR doors, *safety features for building occupants* have kept pace with other protective advances.

Fire doors should be checked periodically, to make sure they are in best operating condition. But out-dated fire doors, at best, can give you only part of the protection you may need. Kinnear AKBAR Steel Rolling Fire Doors, available in any size (within U/L limits), are labeled by Underwriters' Laboratories, Inc.

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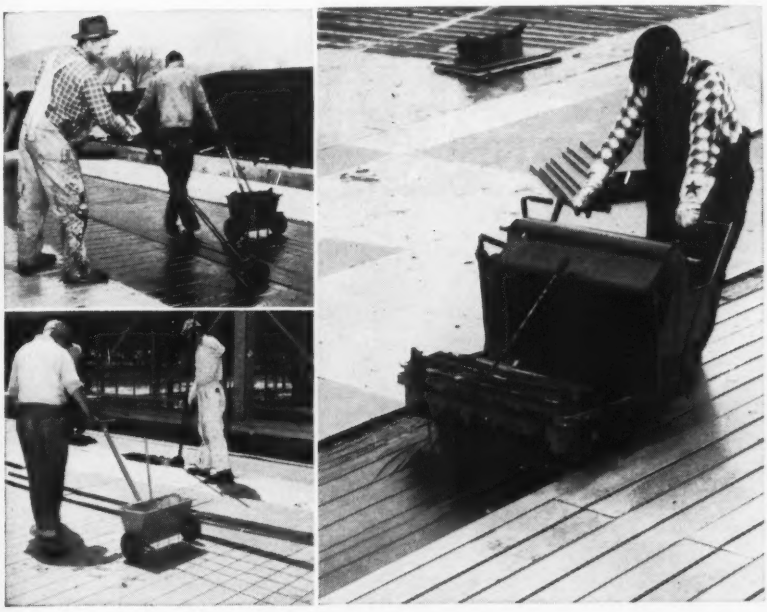

Pictures. (Right.) Lexsuco Applicator applies vapor barrier and adhesive for large jobs in a 3 in 1 operation. (Top left.) For smaller jobs, the semi-mechanical method is used to apply vapor barrier and adhesive with Spreader and Roller Coater. (Bottom left.) Lexsuco Spreader applies adhesive to secure insulation.

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Engineered Applications Save Time and Money

LEXSUCO'S engineered application methods cut labor costs and speed up work in applying Lexsuco Fire-Retardant Roof Constructions on large or small jobs. Lexsuco products are reliable and job proven.

Remember, with or without a vapor barrier, Lexsuco Roof Constructions provide assured fire protection as tested and accepted by Factory Mutual Engineering Division and Underwriters' Laboratories, Inc. Write us for complete information or call your Lexsuco Representative.

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- More for Your Roofing Dollar
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- Better Roof Construction

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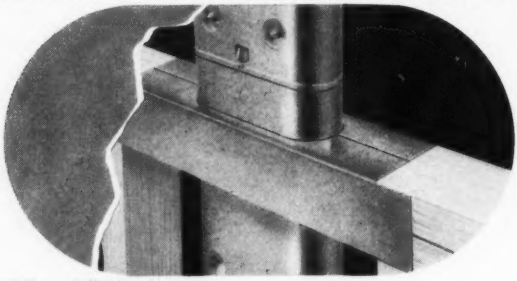
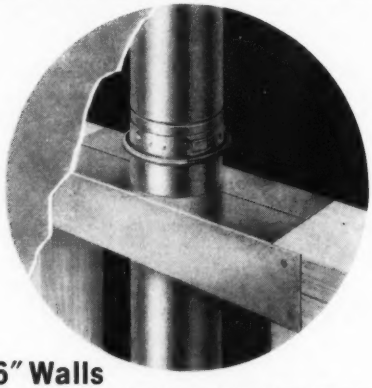
NOW LISTED FOR IN-WALL CONSTRUCTION

Metalbestos offers two complete systems for in-wall gas venting
—everything from draft hood to "bird-proof" Belmont top . . .



In 2″ x 4″ Walls
4″ Metalbestos WV Oval with integral "raised" and firestop spacers



In 2″ x 6″ Walls
Metalbestos 4″ RV Round with integral "lip" and firestop spacers

The "Safety System" Gas Vent Tables

For quick in-the-office or on-the-job check-out, write for a complimentary copy of this clear, easy-to-use reference for correct gas vent installations of all types. These tables give accurate data on correct sizes, lengths and connections to provide proper design and safe installation of efficient venting systems. Ask too for Bulletin 102 on installation details.

UL

METALBESTOS
DIVISION
WILLIAM WALLACE COMPANY, BELMONT, CALIF.
MANUFACTURING PLANTS IN BELMONT, CALIF., LOGAN, OHIO

VICTAULIC

METHOD OF PIPING

VICTAULIC COUPLINGS

Styles 77, 77-D for standard applications. Simple, fast to install — sturdy and reliable. Sizes ¾" to 30". Style 75 Light-Weight Couplings for light-duty applications. Sizes 2" to 8". Additional styles for cast iron, plastic and other pipes. Sizes through 60".

ROUST-A-BOUT COUPLINGS

Style 99 for plain or beveled end pipe. Best engineered, most useful plain end joint on the market. Simple, husky — easy and fast to install. Takes strong bull-dog grip on pipe. Sizes 2" to 12".

VICTAULIC FULL-FLOW FITTINGS

Complete line of Elbows, Tees, Reducers, Laterals, etc. — to fit all Victaulic Couplings. Streamlined for top efficiency, easy to install. Sizes ¾" to 12".

VIC-GROOVER TOOLS

Handy, on-the-job grooving tools that do the job in half the time. Light weight, easy to handle — operate manually or from any power drive. Automatic groove position and depth. Sizes ¾" to 8".

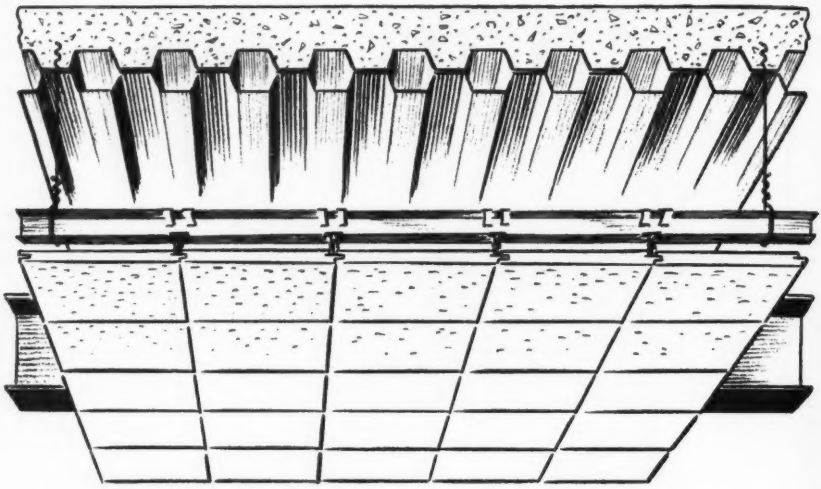
APPROVED BY:

Underwriters' Laboratories, Inc.
Factory Mutual
New York City Board of Standards and Appeals, Cal. #413-53-SM.

Proven for 28 years on both wet and dry Fire Protection Systems. Standard with most major sprinkler companies for bulk-run and cut-in piping. Victaulic Couplings are installed in *less than one-half the time* required for other standard pipe joints.

THE EASIEST WAY TO MAKE ENDS MEET

VICTAULIC
COMPANY OF AMERICA
P.O. Box 509, Elizabeth, N. J.



Armstrong Acoustical Fire Guard provided five-hour protection for structural steel when tested by Underwriters' Laboratories, Inc. (Retardant Test #4177-2). Floor-ceiling assemblies using Acoustical Fire Guard as the only protective element beneath the structural members have received one-, two-, and four-hour time-design ratings.

New Acoustical Ceiling Tile Forms Effective Fire-Retardant Membrane

Armstrong Acoustical Fire Guard is an acoustical ceiling tile which retards the passage of flame and dangerous transmission of heat. It is the first and only time-design-rated acoustical ceiling tile.

Floor-ceiling assemblies using Acoustical Fire Guard as the only protective element beneath the structural steel have received one-, two-, and four-hour time-design ratings from Underwriters' Laboratories, Inc. By eliminating the additional fire protection that used to be required between the suspended acoustical ceiling and the floor slab above, Acoustical Fire Guard makes possible significant savings in construction time and cost.

Since it was introduced one year ago, Armstrong Acoustical Fire Guard has been chosen for millions of square feet of ceilings in all major types of buildings across the country. If you would like to learn more about this remarkable ceiling, contact your nearest Armstrong district office or write to Armstrong Cork Company, 4201 Woodbridge Street, Lancaster, Pa.

Armstrong ACOUSTICAL CEILINGS

1860-1960—Beginning our second century of progress

15 pound Trigger 15 pound Squeeze Valve

NEW KIDDE CARBON DIOXIDE PORTABLES AWARDED HIGHEST U.L. RATINGS!

Belleville, N. J. — A spokesman for Walter Kidde & Company announced here today that four of the company's new portable fire extinguishers have been awarded the Underwriters' Laboratories highest ratings for their respective capacities. To those interested in fire safety, this means that, pound for pound, these new Kidde units have more fire-killing power than any other carbon dioxide extinguishers on the market today.

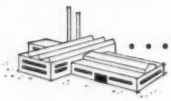
Available in 15 and 20 pound capacities, in either squeeze valve or trigger models, these power-packed Kidde units feature new hose and discharge horn assemblies, which are responsible for their extra fire fighting ability. The new assembly is supplied also with Kidde's 10 pound carbon dioxide portable which has a U. L. rating not exceeded by any other extinguisher of its capacity. This hose-horn combination is also being offered as a replacement unit for existing 10, 15 and 20 pound carbon dioxide units, and when attached will upgrade their effectiveness equal to the new ratings.

For more information on these top-rated Kidde carbon dioxide portables write Kidde today.

Kidde (K Kidde)

Industrial and Marine Division
Walter Kidde & Company, Inc.
151 Main St., Belleville 9, N. J.
Walter Kidde & Company of Canada Ltd.
Montreal — Toronto — Vancouver

ROCKWOOD SPRINKLERS



. . . protect lives and property

. . . cut insurance cost

. . . pay for themselves

Fire in any building you manage — commercial, industrial or institutional — may result in losses which cannot be replaced.

You can avoid these losses — and make additional savings — by installing Rockwood Sprinklers.

Over 18 million Rockwood Water-FOG Sprinkler Heads have been installed for the protection of thousands of buildings, hundreds of thousands of lives and millions of dollars worth of property. Their proved efficiency is recognized by fire insurance companies, which grant substantial reductions in premium rates on all properties equipped with them. Another money-saving advantage is the elimination, in many communities, of fire doors, fire walls and other additions required in new construction, particularly in public buildings.

Rockwood can engineer a complete fire protection system to meet your particular needs and to handle any special fire hazards. The savings it brings you will be as continuous and sure as its protection. Out of premium reductions alone, your entire installation may pay for itself. And your working capital can be protected by deferred payments. Tested and listed by Underwriters' Laboratories, Inc. For further facts, write to Rockwood Sprinkler Company, 3007 Harlow St., Worcester 5, Massachusetts.

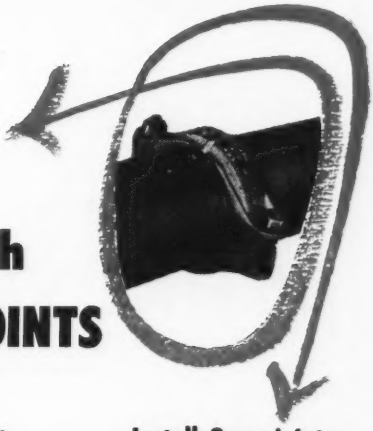
ROCKWOOD SPRINKLER COMPANY

A Division of the Gamewell Company

Engineers Water . . . to Cut Fire Losses

Branch Offices in all principal cities

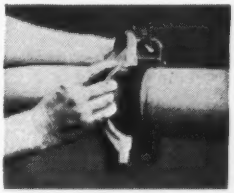
Couple Pipe the Easy, Low Cost Way with New G-B GRUVAJOINTS



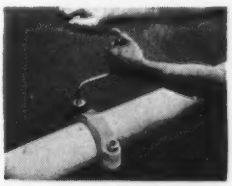
Now you can save up to 25% when connecting pipe for bulk runs and risers. Yes, contractors are saving money every day when they use new lightweight Gruvajoints. There's no flanging, no threading, no welding, and there's no need for heavy chain tongs or pipe wrenches. Gruvajoints are truly the modern way to couple pipe. Write today for free illustrated brochure on G-B Pipe Coupling Products. Gruvajoints are now available in 2", 2½", 3", 4", 5", 6" and 8" sizes.

Install Gruvajoints in three easy steps

Grease gasket and center over pipe ends.



Lay housing halves into grooves and insert bolts.



Tighten the two nuts equally.

LISTED by
Underwriters' Laboratories, Inc.
File EX 1741A and B

APPROVED by
Factory Mutual Engineering Division
Report Serial No. 13097

GUSTIN-BACON
manufacturing company
266 W. 10th St. Kansas City, Missouri

The
"MINUTE MEN"
of FIRE PROTECTION

UPRIGHT MODEL SSU
Write now for complete information

GRIMES SPRINKLERS stand guard over your life and property 24 hours of every day, year after year after year. It is comforting to know they are always dependable and ready to go into action at a minute's notice! Because GRIMES Fire Sprinkler Systems and Equipment are engineered for better protection.

Through the years, GRIMES has earned a reputation for designing, developing and manufacturing the newest and most improved sprinkler equipment available.

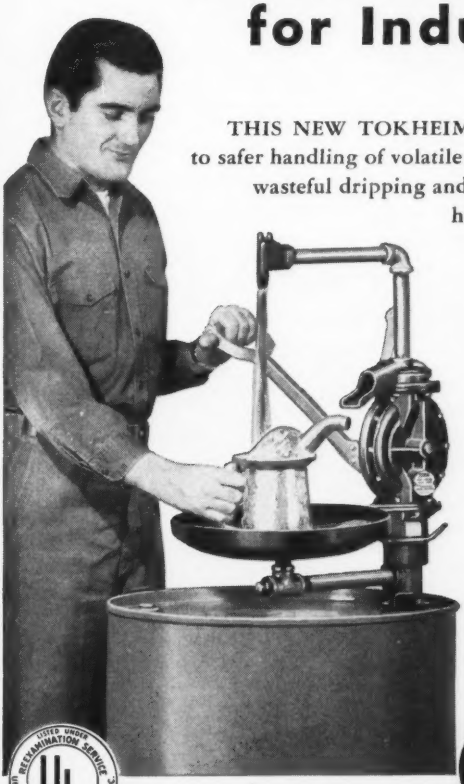
GRIMES devices are approved by all insurance interests everywhere. Learn how much modern engineering can do for safe, sure fire protection and how the cost of GRIMES installations pay for themselves out of savings in insurance premiums in comparatively short periods of time.

RAISLER
SPRINKLER DIVISION

RAISLER CORPORATION, 750 Third Ave., New York 17, N.Y.
Licensees in all principal cities in the United States and Canada

SAFER

liquid handling for Industry



THIS NEW TOKHEIM HAND PUMP contributes to safer handling of volatile liquids wherever used. Stops wasteful dripping and slippery floors. Reduces fire hazard and accidents common to other methods of liquid transfer. Approved for handling petroleum liquids —ideal for many others. Available in 22 different models for 'most any use— from pipe lines to drums, or underground tanks, with hose or spout outlets. Order from your dealer, your oil company, or your Tokheim representative.

Write factory for literature.

QUALITY TOKHEIM HIGH VACUUM HAND PUMPS

General Products Division

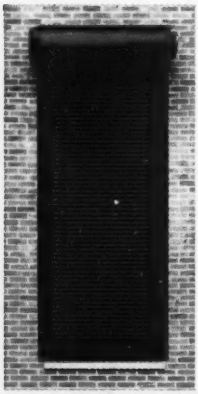
TOKHEIM CORPORATION

DESIGNERS AND BUILDERS OF SUPERIOR EQUIPMENT SINCE 1901

1585 WABASH AVENUE FORT WAYNE, INDIANA

Subsidiaries: Tokheim International, A. G., Lucerne, Switzerland; GenPro Inc., Shelbyville, Indiana; Tokheim of Canada, Ltd., Toronto, Ontario

Automatic Rolling Steel
FIRE DOORS *and* WINDOW SHUTTERS
PREVENT SPREAD *of* FIRE!



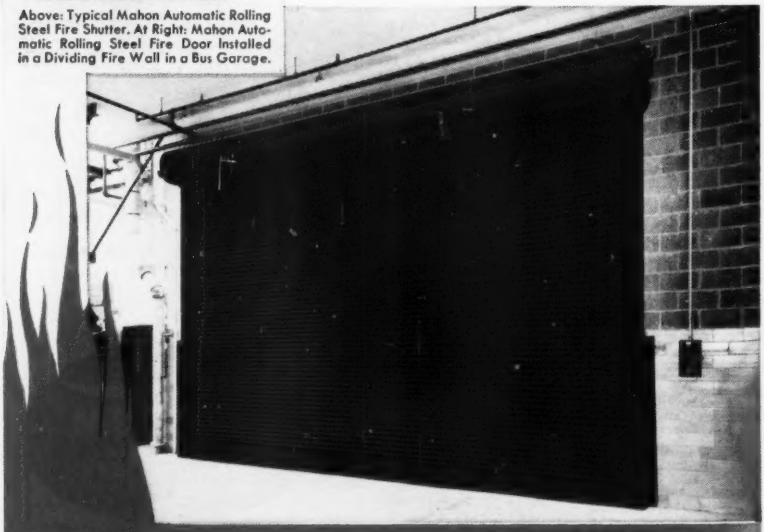
You need good automatic fire doors in fire walls, corridors, and vertical shafts . . . in some cases automatic rolling steel window shutters are necessary to protect your building and its contents from fires which may originate in nearby buildings. Many, many cases are on file which confirm that timely action of automatic rolling steel fire doors and window shutters have confined a fire to its point of origin and permitted its being extinguished with comparatively small damage. Make a survey of your building now, and don't delay action. You will find a Mahon Automatic Rolling Steel Fire Door or Window Shutter to meet each of your requirements—all bear the Underwriters' Label. These automatic fire doors may be operated manually or mechanically in every day use. If a fire should break out while they are in the open position, the automatic mechanism will close the door, cutting off drafts and preventing the spread of the fire. See Sweet's Files for complete information, or write for Catalog G-60.

THE R. C. MAHON COMPANY • Detroit 34, Michigan

Branch Offices in New York, Chicago, Los Angeles and San Francisco
Sales Representatives in All Other Principal Cities

Manufacturers of Standard and Underwriters' Labeled Automatic Rolling Steel Fire Doors and Window Shutters; Underwriters' Rated Metalclad Fire Walls; Insulated Metal Curtain Walls; Electrified M-Floors; Steel Roof Decks; Acoustical Long Span M-Decks; and Acoustical and Troffer Forms.

Above: Typical Mahon Automatic Rolling Steel Fire Shutter. At Right: Mahon Automatic Rolling Steel Fire Door Installed in a Dividing Fire Wall in a Bus Garage.



MAHON ROLLING STEEL FIRE DOORS and WINDOW SHUTTERS

Where there's smoke...

it's almost certain one or more of the dependable, high-quality fire fighting products... known by these famous brands... will be called upon to fight the fire!

Consolidated under a single organization, these brands comprise the most complete line of competitively-priced fire protection products and services ever offered. This means you can guard against every fire risk by contacting a single source for all these products: approved fire extinguishers; automatic sprinkler systems; carbon dioxide, dry chemical and foam systems; fire hose, nozzles and couplings; alarm systems; and fire department accessories including ladders, sirens, clothing, breathing apparatus, first aid kits, etc.

Representatives of this broad product line, with their depth of knowledge and experience in all industrial, commercial, institutional, municipal and household fire hazards, are uniquely qualified to *survey, analyze* and *recommend the proper equipment* for every fire protection requirement. To contact the representative nearest you, look in the yellow pages under "Fire Protection Equipment" or write to:

THE FYR-FYTER COMPANY

ATLANTIC COAST REGIONAL OFFICE
P. O. Box 750, Newark 1, New Jersey

CENTRAL STATES REGIONAL OFFICE
221 Crane St., Dayton 2, Ohio

PACIFIC COAST REGIONAL OFFICE
132-140 Hawthorne St., San Francisco 7, Calif.

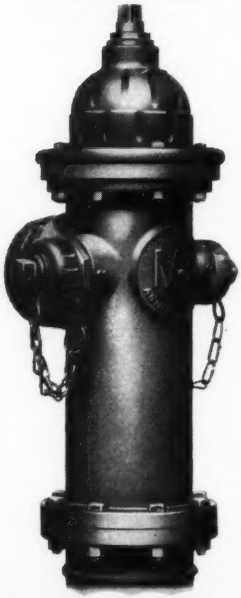
BRANCHES: Atlanta, Baltimore, Boston, Chicago, Dallas, Dayton, Detroit, Los Angeles, New York, Newark, Philadelphia, Pittsburgh, Portland, Rochester, San Francisco, Seattle, Toronto (Ontario). Representatives and Distributors in all principal cities.

ALWAYS-READY GUARDIAN OF *LIFE AND PROPERTY*

MH

COMPRESSION TYPE FIRE HYDRANT

Above: Standard Model.
Below: Traffic Model.



Although an M & H Fire Hydrant may stand idle for years, without a moment's notice it functions perfectly. Its simple rugged design and careful manufacture from highest quality materials is the reason.

Large diameter, unobstructed waterway gives high flow efficiency when large volume of water is needed to fight fire. All operating parts are bronze or bronze bushed. Furnished either in accordance with A. W. W. A. specifications or Underwriters and Factory Mutuals approved; also either standard model, traffic model or flush type. For complete information, address

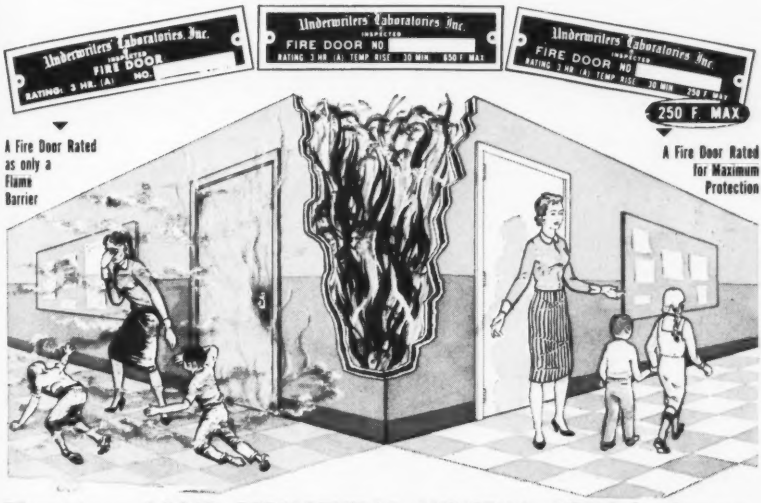
M&H VALVE AND FITTINGS COMPANY
ANNISTON, ALABAMA

SUBSIDIARY OF W WALWORTH

MAXIMUM FIRE DOOR PROTECTION

to Save Both Life and Property

. . . depends on UL Heat Transmission Ratings!


Underwriters' Laboratories, Inc.
FIRE DOOR
Underwriters' Laboratories, Inc.
FIRE DOOR NO
Underwriters' Laboratories, Inc.
FIRE DOOR NO
250 F. MAX
A Fire Door Rated as only a Flame Barrier
A Fire Door Rated for Maximum Protection

There's a SOLID STRUCTURAL MINERAL CORE in Every

D-H PyroDor®

At No Extra Cost!

To Insure LOWEST HEAT TRANSMISSION RATING*

*Underwriters' Laboratories test and rate fire doors strictly on a performance basis . . . enabling architect, insurance rating and fire prevention authorities to select a door for maximum protection. Recent fire tests for D & H PyroDors rated heat transmission with a temperature rise of 110°F. at the end of 30 minutes of fire exposure — *140°F. better than the maximum allowable under UL Standards.* Demand your fire doors to be rated for the lowest heat transmission — available *at no extra cost* with D & H PyroDors.

In numerous fires of recent years, many lives were lost not by flame alone, but by excessive transmitted temperatures. For the full story and complete information on fire doors, frames and hardware, request FREE Catalog DHS-2060.

Call your nearby D & H Distributor — Consult the Yellow Pages or Sweet's Architectural File, or Write direct.

D-H DUSING & HUNT, Inc.

The Most Complete Line of Flush Doors

67 Lake Street — Le Roy, New York

NOTIFIER

presents

NEW

N-CO-BELL®

Underwriters' Laboratory Listed

CREATED with IMAGINATION not IMITATION

• SUPERIOR • DIFFERENT • COMPELLING

N-Co-Bell's controlled stroke provides superior gong vibration producing a distinctive and arresting sound. An unusually low amperage drain permits the use of 2 or 3 times as many bells per ringing circuit as other bells.

CONSIDER THESE FACTS - - -

- The 6 volts D.C. Bell draws only 0.14 ampere
- The 12 volts D.C. Bell draws only 0.07 ampere
- As many as 25 N-Co-Bells can be rung at less than 2 amps 12 volts D.C. at the power source.

CHARACTERISTICS

All N-Co-Bells are underdome with handy-mount features
Either pig-tail or plug-in wiring connections
Simple but effective "O" ring weather-proofing
Available in any normal A.C. or D.C. voltage
Sizes 6-8-10 and 12 inch
All size gongs interchangeable
Numerous models—all available for quick delivery
Contactless type A.C. bells for parallel or series operation are available in 12-24-48-120 and 220 volts A.C.
Underwriters' Laboratories listed for both fire protection and electrical use.

N-CO-BELLS mean ECONOMY

You pay no more for a QUALITY N-CO-BELL than an ordinary bell.

Compare our prices with other high quality bells.

No extra charge for distinctive sound performance.

Write for particulars * * * Order your sample

NOTIFIER CORPORATION
3700 North 56th St. Lincoln, Nebraska

NOTIFIER FIRE ALARM

IN ALL ITS RELIABILITY!

Every minute of the day and night, Reliable automatic sprinklers are acting as miniature fire control teams . . . standing ready to automatically detect, sound the alarm, and extinguish fires in their incipient stages.

This is the kind of Fire Control that is absolutely RELIABLE! For over thirty-five years, Reliable Automatic Sprinklers have been guarding life and property from threat of fire . . . without one report of failure.

The complete Reliable Line offers a wide selection of automatic sprinkler devices for every condition . . . including Spray, Sidewall, Conventional and Open Sprinklers; Alarm Valves; Dry Pipe Valves; Accelerators; Mechanical and Electric Alarms; and a full line of sprinkler accessories.

For perfect FIRE CONTROL . . . Let your local Reliable Licensee show you the RELIABLE FIRE CONTROL TEAM . . . We'll see that he contacts you promptly.

Licensees in principal cities of the U.S., Canada, and foreign countries.

THE RELIABLE AUTOMATIC SPRINKLER CO. INC.

Manufactured and Distributed by

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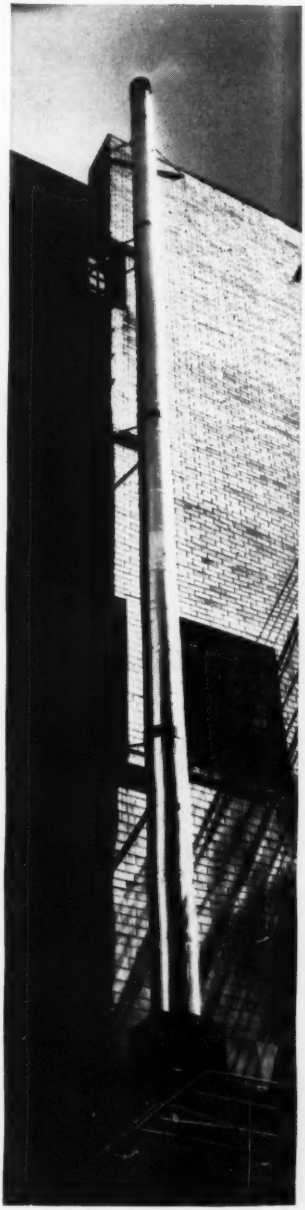
VAN-PACKER
MODEL HT
SMOKESTACK
now listed by
UNDERWRITERS' LABORATORIES



Wherever you see a Van-Packer Model HT Prefabricated Refractory Smokestack specified for boilers, furnaces and incinerators, you can be sure it will give safe and reliable service. Van-Packer Model HT Smokestacks meet the high standards required to earn listing by Underwriters' Laboratories, Inc.

Write for data on Underwriters' Laboratories listing of Van-Packer Model HT Smokestack

VAN-PACKER®

Division of:

FLINTKOTE

Manufacturers of Diversified Products for Home and Industry

VAN-PACKER CO., 30 Rockefeller Plaza
New York 20, New York • PLaza 7-5500

In the West: *Pioneer Division, The Flintkote Company, P. O. Box 2218, Terminal Annex, Los Angeles, Calif.*
In Toronto, Ontario: *The Flintkote Company of Canada, Ltd.*

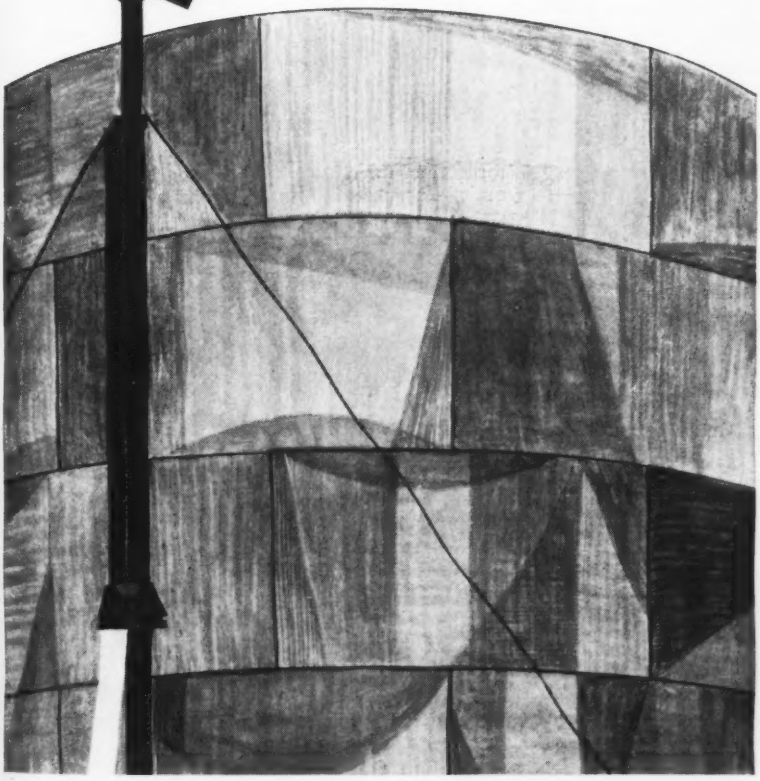
do your foam towers measure up to these standards?

1. Are they built to withstand extreme rough treatment? ☐ Yes ☐ No
2. Would you feel confident in a high wind? ☐ Yes ☐ No
3. In the emergency, can you handle mechanical or chemical foam with the same gooseneck, without requiring "extras" for this purpose? ☐ Yes ☐ No
4. If yours are the "detachable" type of gooseneck, can you accomplish the "detaching" operation without having personnel beneath it, where they might be struck if the goosenecks dislodges and falls? ☐ Yes ☐ No
5. Are your goosenecks of heavy gage stainless steel, built to take the high heats of a flammable liquid fire? ☐ Yes ☐ No

if you can answer yes in all cases, you already have National Aer-O-Foam Towers. If not, you need them! For full information, write for Booklet G.

NATIONAL FOAM SYSTEM, INC.

West Chester, Pa.



Kuhns

NOW... ductile iron fittings

For Sprinkler Systems

Kuhns ductile iron pipe fittings—the newest development in piping—provide an extra margin of operating safety for sprinklers, high pressure lines and other vital piping systems. High structural strength and resistance to thermal shock help these fittings prevent leakage caused by vibration, temperature changes or misalignment.

"K" Pipe Lock Couplings

Listed for 800 psi by Underwriters' Laboratories, Inc., these couplings have a safety factor of five times the UL listing for 2½" through 6" and four times UL listing for 8". Sizes: 2½" through 8". Look for the "800 D" on each.

"K" Flanges and Flanged Fittings

Pressure rating, 500 psi by Underwriters' Laboratories, Inc. for elbows, base elbows, 45° elbows, side outlet elbows, tees, side outlet tees, and reducers in straight and reducing sizes. Flat faced flanges standard. Extra heavy flange dimensions and raised faces available. Look for the "DI 500" on each.

Complete range of sizes through 12".

"K" Screwed Fittings *

Pressure ratings listed by Underwriters' Laboratories, Inc.

STEAM AND OIL AT 550°F
¼" to 3".....300 lbs.
LIQUID AND GAS AT 150°F
¼" to 1".....2000 lbs.
1¼" to 2".....1500 lbs.
2½" to 3".....1000 lbs.

*Ductile iron fittings are available in any size in Kuhns complete cast iron line, ¼" through 12".

Note: These fittings are excellent for liquefied petroleum gas systems. Look for the "DI 300" on each.

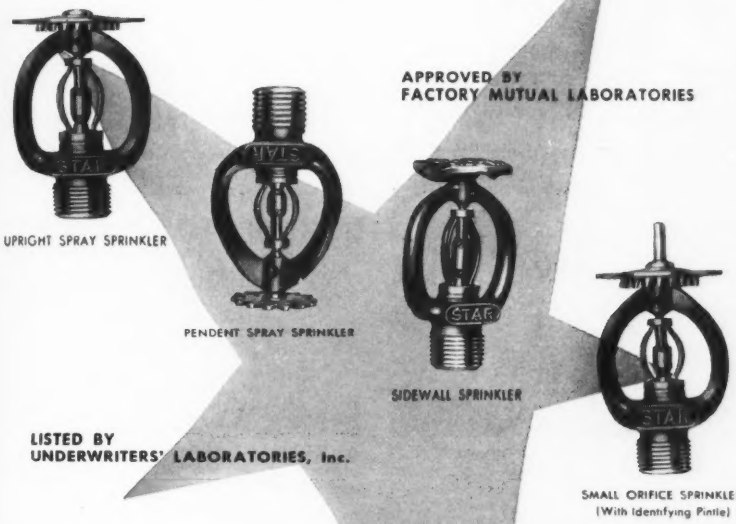
Send for our catalog or contact your wholesaler.

K

THE KUHNS BROTHERS CO.
1800 McCALL STREET, DAYTON, OHIO

STARGARD

GIVES YOU MORE — FOUR WAYS



1 **SUPERIOR PROTECTION** . . . *due to more efficient water distribution.* Proven by tests under actual fire conditions for all classes of hazards.

2 **MORE EFFECTIVE USE OF LESS WATER** . . . because wider distribution and break-up of the water discharged provides greater cooling and extinguishment.

3 **CEILING PROTECTION BY COOLING — NOT WETTING** . . . All the water goes onto the fire. The break-up of water results in complete cooling and control of flammable vapors.

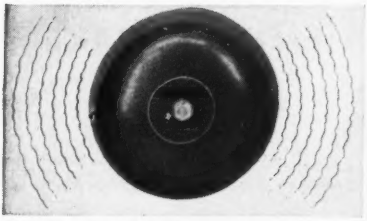
4 **MORE FIRE CONTROL WITH FEWER SPRINKLERS** . . . because ceiling temperatures are kept lower, fewer sprinklers open. Immediate water saturation of the fire area prevents the spread of fire. Hot gases become impotent in the cooled atmosphere.

STAR SPRINKLER CORPORATION

Westmoreland & Collins Sts., Phila. 34, Pa.

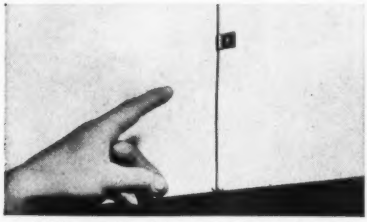
Licensees in principal cities of the United States and Canada

FIRE ALARM!

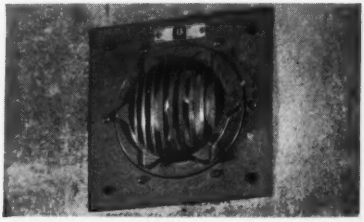


1. Save priceless lives, protect valuable buildings with the Kidde Atmo Fire Detecting and Alarm System!

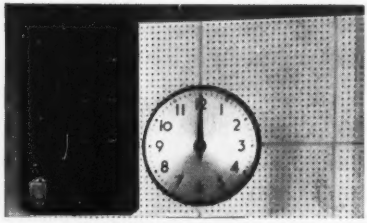
2. This automatic detecting and warning system sounds an alarm instantly at the *first* hot breath of fire!



3. Using rate-of-temperature-rise tubing as a sensing element, the system works without outside power!



4. Kidde's Atmo system can sound alarm at fire area, outside the building or at local fire department station!



5. Kidde's Atmo system also gives fire location at a panel near any manned telephone switchboard!

Kidde Atmo

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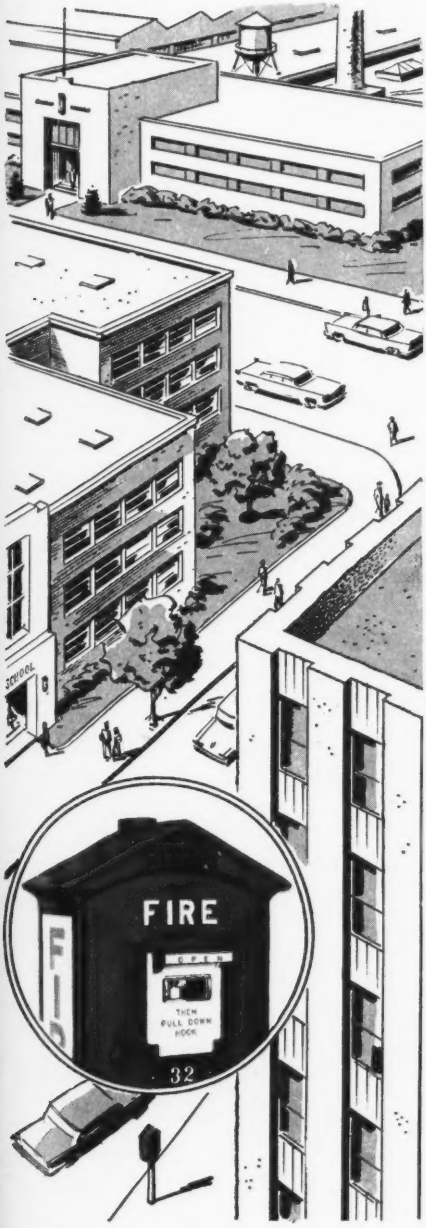

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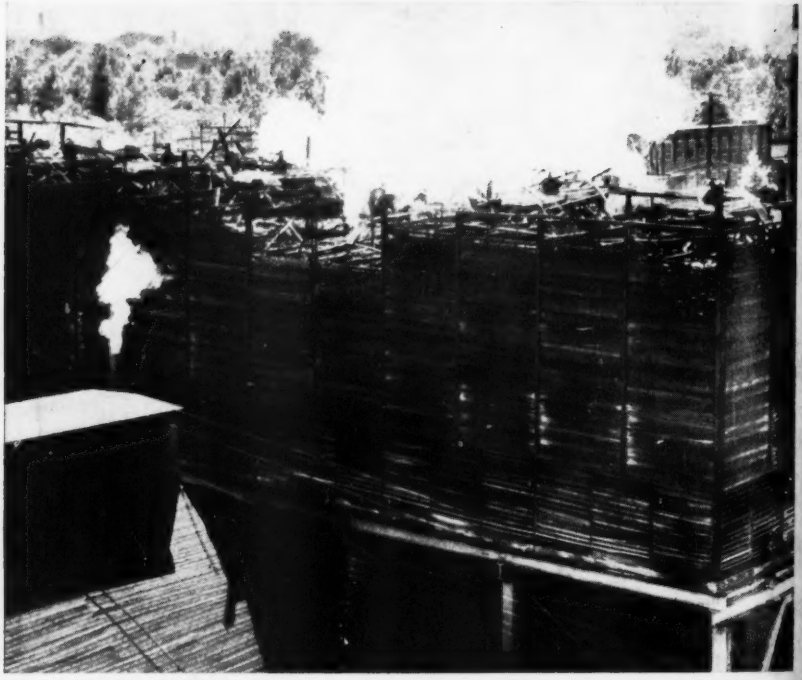

Fire caused by friction spark destroyed top 6 feet of this cooling tower, damaging motors, shafts, gear boxes.

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